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Metals and Alloys

ANNUAL ENGINEERING REVIEW ISSUE

JANUARY 1942

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R-139

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Feature Section—Annual Review Articles

Some of the highlights of "metallurgical engineering's biggest year":

● Emphasis in *steelmaking* has been on increased production, with certain special problems to the fore—Sisco, page 42.

● In *non-ferrous* production, progress was evident in continuous production and annealing—Craig, page 46.

● Numerous *foundry* developments in the making of iron, steel and non-ferrous castings are reported by several authorities—Cone, page 48.

● Demand for forgings of aircraft quality became the prime mover in the *forging* field—Naujoks, page 52.

● Atmospheres, induction heating and electric salt baths feature *heat treating* progress—Conradi, page 54.

● Notable in *machining* were changes in tool steels and greater use of automatic machines—Woldman, page 56.

● 1941 brought vast expansion in the use of *welding*, and increased technical research—Hoyt, page 58.

● Stringency-impelled development of new finishes and expansion in the surface treatment of light metals marked the *finishing* field—Burns, page 60.

● Modifications in metal-design of *aircraft* resulted through scarcities on the one hand and shift to mass production on the other—Titterton, page 65.

● *Substitutions in product design*, intensively applied in all industries, are assembled in a 15-page symposium by 8 authors, with a special reference table—page 67.

● More than 80 *new materials and finishes* are tabulated in an 8-page reference section—Peters, page 82.

● Broadened use of radiography, new gages and intense interest in hardenability featured the *testing and inspection* field—Stokley, page 82.

● The trend toward control of the end-result rather than intermediate conditions stood out in *instrumentation*—Bradley, page 94.

Metallurgical Engineering Digests

German Hot Blast Fizzles in England

In his original article on foundry developments in recent years, Faulkner (page 130) reported that the Germans had tried to introduce the hot blast in England—but that it had failed miserably. Sounds to us like a classic among double-meaning statements!

Air Conditioned Blast Furnace

A "first report" of his company's experience with an air conditioning system on a blast furnace by Miller (page 134) indicates that substantial increase in production, decrease in coke consumption and improvement in uniformity were obtained.

Spot Welding Contacts

Contacts are important, particularly in spot welding, and "contact resistance" is deftly probed by Tylecote (page 144) to observe the effect of electrode pressure and temperature changes on the resistance to electric flow in spot-welding.

When the Welding Torch Doesn't Weld

A composite digest on flame-processing (page 148) records the wide extension of the "welding torch" to a variety of non-welding jobs like flame-hardening, flame-softening, flame-cutting, etc. Much information on modern practice is given.

Nitriding with Urea

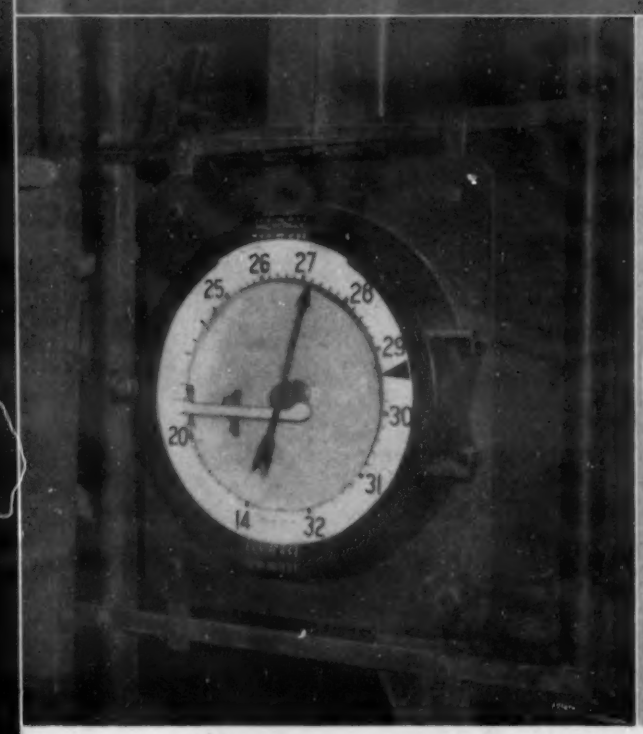
Urea as a source for ammonia in nitriding is studied, with encouraging results, by Dunn, Mackay & Dowdell (page 152). Urea derivatives, too, are good ammonia generators, as any domestically inclined father of a 1-yr.-old can ruefully testify.

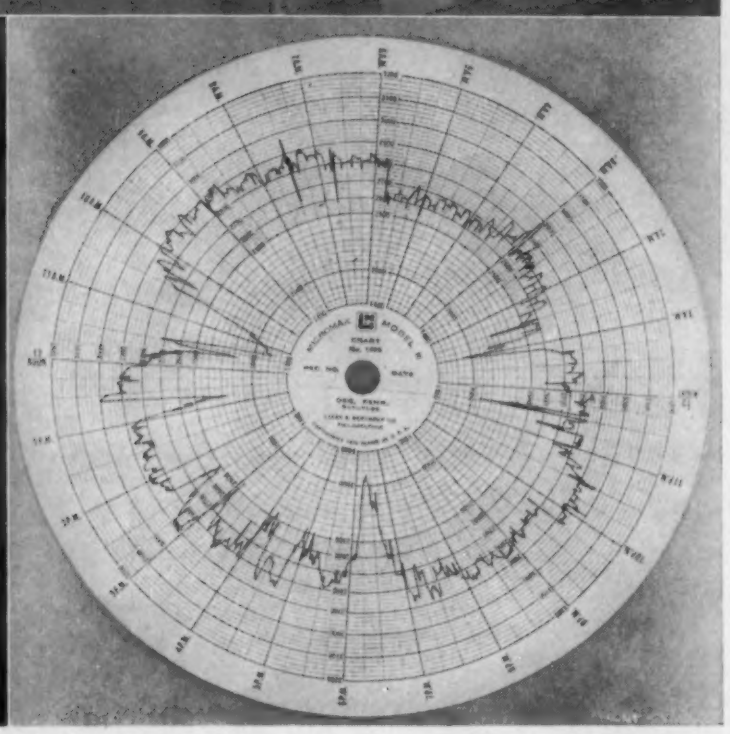
Machining Shells with Carbide Tools

The great utility of cemented carbide tools in speeding the production of shells and other munitions is dependent on proper manipulation, reports Judkins (page 157), who describes good practice.

Design for Stampings

The design and material considerations for employing stampings in today's products are cited by Moslander (page 178).





Top: Mounted outside the furnace, Rayotube watches temperature of furnace roof.
Left: The Number One Helpers can read open-hearth temperature easily on the big dial of this Micromax Recorder.
Right: Typical record of one day's operation.

FIRST HELPERS "ELECT" MICROMAX TO WORK IN O-H SHOP

Given a chance to use Micromax pyrometers in their shop, the First Helpers of Empire Sheet & Tin Plate Co. at Mansfield, Ohio, have turned in their verdict. They like the Micromax. They use it constantly; it helps them hold a heat more even, and make it in less time. They can see, when they come on shift, exactly where the heat stands and what has happened to it. Micromax substitutes fact for guesswork; enables the men to do a better job.

The equipment is simple and fool-proof. A Rayotube is mounted well above the bath level at the back of the furnace, so that it points at the roof through a hole in the furnace wall. It is connected, like a thermocouple, to a Micromax Recorder, and lasts indefinitely.

The equipment can, if desired, be used also for automatic control and many such installations have been made. If you're interested in either recording or controlling, ask for Bulletin N-33B-600B.

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Heat-Treater lowering the cover of Raymond M[illing] Division's Homo tempering furnace. Springs [are] brought to heat quickly and uniformly by Hom[o] forced-convection heating.

Spring Maker Prefers Homo Method for Accurate Uniform Spring-Temper

Tempering of springs is an art which h[as] been practiced by the Raymond Mfg. Co., D[i]vision of Associated Spring Corp., Corry, P[a] for 50-odd years, but the one temperi[ng] method preferred today in this plant is t[he] Homo Method.

For, when a spring gets to the Homo, i[t] will automatically receive the treatment whic[h] the heat-treater's experience and skill tell hi[m] it should have. He sets the temperature dia[l] and a time-signal too, if he wishes; then h[e] can forget the batch until the signal cal[ls] him to unload the furnace. His time an[d] skill are freed for other duties—"stretched" to help meet today's multiplied demands.

The Homo requires practically no atten[-] tion; it runs almost continuously, taking wor[k] in any order, and jumping from one tem[-] perature to another at a turn of the hand. I[t] has never yet produced a Raymond spring which was rejected for temper, but its auto[-] matically-made record of time and tempera[-] ture is always available and is a valuable operating record.

On the Homo Method Controller's chart is a per[-] manent record of time and temperature of drawing for each batch tempered.

Homo Method equipment is made in sizes and capacities for practically any parts-tempering need, and is so widely used that we can probably arrange for any interested person to inspect a comparatively nearby in[-] stallation. So, if you have a parts-tempering problem, get in touch with us. If you'd prefer a catalog, just ask for No. T-625, "Homo Tempering."

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In Our Stride

Those of us who are old enough to recall World War I can contrast the country's excited attitude upon our entry then with its matter-of-fact attitude upon entry into World War II. It has long been plain that there was a job to do; now we're doing it. Preparation for doing it has been going on, not only in the things one can see, but in those one can't see, i.e., in our mental attitude.

We are thoroughly ready to put first things first. The metallurgical industries have already had so much readjustment that the events of December 8 to 11, 1941, cause almost no change in plans; these industries have only to take the situation in their stride. That the job will be a long one and a nasty one has been very clear. Instead of stopping to take time out to sing patriotic anthems and listen to pep talks, the country is spitting on its hands and buckling down to the job.

It is heartening to be able to think and talk of offense rather than being restricted to the past euphemisms of "defense" and "the emergency." Offense is a better word than defense; *war* is what the enemies have asked for and will get.

The definition of modern war is the use of metals in offense. We have more metal than our enemies. We hate to waste it in that way, but that is, for the moment, the best use to which it can be put.—H.W.G.

Credit Where Credit Isn't Due

Our ire is roused by a sentence in an article "Uncle Sam goes Prospecting" by F. R. Bechdolt in the Nov. 15, *Saturday Evening Post* which reads: "The Bureau of Mines discovered that in some cases molybdenum can be used as a substitute for tungsten."

"Discovered" implies priority, deserving of credit. The correct word would be "recognized."

The "discovery," as generally happens in metallurgy, was the progressive outcome of a long succession of experiments in many hands.

(Continued on page 37)

Beginning the 100th Year of Ryerson Steel-Service

Large and complete stocks, steel of known quality, prompt and dependable service.... these are the rugged cornerstones on which the Ryerson business has been built. 100 years of experience is at the disposal of Ryerson customers to help them meet every steel problem. Today, our stock in many lines is depleted and war needs have the right of way. However, we continue to serve every customer to the best of our ability in accordance with the Government Program. Joseph T. Ryerson & Son, Inc., Chicago, Milwaukee, St. Louis, Cincinnati, Detroit, Cleveland, Buffalo, Boston, Philadelphia, Jersey City.

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Alloy and Tool Steels
Heat Treated Alloy Steels
Strip Steel, Flat Wire, etc.
Stainless Steel
Mechanical Tubing
Boiler Tubes and Fittings
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It has been discussed by Gregg in "The Alloys of Iron and Molybdenum." He cites a clear statement by Thallner of Bethlehem in 1901 that molybdenum was a substitute for tungsten in high speed. Molybdenum high speed was studied by Taylor and White in their classic experiments before 1907; by J. A. Mathews, at about the same period; and its utility was loudly proclaimed by Arnold and Ibbotson in 1919.

It took the extensive work of Ritchie at Watertown Arsenal, of Emmons at Cleveland Twist Drill, and of many others to bring out the full facts and establish molybdenum high speed in its present position of a very acceptable replacement for tungsten.

The writer worked on molybdenum steels for the Bureau of Mines in the days before Ritchie and Emmons made their developments, but that work was aimed at constructional, not high speed steel, and made no discoveries whatever about the replaceability of tungsten by molybdenum.

The Bureau of Mines is making enough efforts along constructive lines not to need credit for the discoveries of others. That's the sort of thing we expect from politically-minded New-Deal agencies, not from old, established, technical, branches of the Government service.

Nothing would have grieved Dr. J. A. Holmes, the first Director of the Bureau of Mines, more than to have had his men put in the position of seeking or taking undeserved credit.—H. W. G.

Crystallization Again!

Mr. K. E. Luger calls our attention to a note in the September issue of the *Petroleum Engineer,* page 144, aimed at increasing the service life of tubing strings. The note is headed "Heat-Treating Crystallized Tubing to Decrease Breakage," and in the body it is stated: "In nearly every instance where tubing strings had parted it was noted that the break occurred at the base of the threads, due undoubtedly to a crystallized condition in the metal at this point."

Two steps are employed in reconditioning the tubing for further use, first the ends are normalized from 1400 to 1600 deg. F., then the old threads are cut off, leaving only one or two threads to engage the dies in rethreading. The upset portion of the tubing is long enough to take the second set of threads.

Without calling on the old misconception of "crystallization," or the more correct phraseology of "damage," it is good horse-sense to cut off the old threads, because it is difficult to inspect for tiny cracks at the base of the threads. The normalizing operation doubtless does no harm, and probably doesn't do a bit of good, for it is difficult to see how any work-hardening that would extend to the base of the new threads could have taken place on the upset portion.

One wonders why some enterprising maker of tubing doesn't recognize the good sense of rethreading and supply tubing with enough upset length to take three or four sets of threads instead of just two.—H. W. G.

Metallurgical Engineering's Biggest Year in Review

The week of December 7th, 1941, will eventually be cited by many chroniclers as the most momentous in United States history, for within that week we as a nation came to death-grips with mushrooming totalitarianism and took our place at Armageddon.

But worth italics in any history of these times is *the engineering story of the first 48 weeks of 1941* — a shining record of metal-industries activity and engineering achievement that for the first time in its military annals gave this country substantial supplies of war weapons and a far-flung munitions-production "know-how" *before* hostilities began.

This first annual engineering review issue of METALS AND ALLOYS, therefore, is proudly dedicated to the resourceful work of America's metallurgical engineers in the heavy-stressed months before the shooting started. Forced to re-alloy, re-design, invent, expand and hold back the clock — in the face of raw material scarcities, machinery shortages, work stoppages and the inevitable unwieldiness of officialdom — and handling such strange products as shells, cartridge cases, gun clips, armor plate and breech blocks in addition to the familiar steel ingots, grinder beds, engine cylinders, turbines, etc. — metal-industry engineers, metallurgists and plant executives richly deserve the highest possible praise for their tremendous 1941 accomplishments.

The engineering and metallurgical problems they faced and solved, the time-saving, material-saving and quality-improving practices they introduced or extended and the new materials and equipment they developed and used during the last year or so are reviewed in the following pages. Because the advent of actual war has but increased the tempo of metallurgical engineering activity, many of the developments described will be even more widely applicable during the critical months ahead.

This special review covers broadly the entire metallurgical engineering field, from blast furnaces through metal-fabrication and product design down to inspection and control. It is divided into four major sections, as follows:

Production of Metals, Alloys and Castings
Fabrication and Treatment Processes
Metal Applications and Product Design
Testing and Control

Each section contains several articles on specific topics. Featuring the "Metal Applications and Product Design" section are a tabular review of new materials introduced during the year and a symposium of several short articles on alternate materials in product design. At the last minute another symposium on metal design trends in war weapons had to be omitted because permission to publish already-prepared articles on ships, guns, tanks and other ordnance products was withdrawn after our entrance into the war.

Much has happened to and through metallurgical engineering in 1941. The present status, as recorded herein, will be an ideal base for 1942 operations — industrial and otherwise. That is why this special review was prepared — to give metallurgical engineers, busy producing the materials and instruments of war, a broad view of their present position as they look ahead to the even more furious future. The contributions are from some of the best engineering minds in the metal industries — given freely to further the one mighty purpose in *all* our minds.

—The Editors.

Now that we're in it — let's win it!

ENGINEERING REVIEW OF 1941 IN THE

Production of Metals, Alloys and Castings

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Tapping pig iron from a large blast furnace.
(Courtesy: Ford Motor Co.)

The Blast Furnace

AN OPEN LETTER FROM ARTHUR G. McKEE

TWO TRENDS have been predominant in the blast furnace industry the past year: Greater output of pig iron to meet the scrap shortage, and air conditioning.

The first of these is being met in part by running blast furnaces to the largest capacity possible and by the plans to build more blast furnaces to increase the total capacity. Rebuilding of some stacks has also

been a factor. The serious phase of this matter is the length of time required to build new furnaces.

As to air conditioning of furnaces—this is gaining in favor. Two companies have had in the last year considerable experience, and others have either taken steps to install equipment or are seriously considering it. One marked advantage is the increased output possible from present furnaces.

An Open Letter

The following open letter to the editor from Arthur G. McKee, president of Arthur G. McKee & Co., Cleveland, is of decided interest:

To the Editor: Some time ago you asked me to write somewhat about the improvements in blast furnace design and blast furnace operation during the year 1941 and I promised to make an effort to do so.

However, "we are in the army now," not actually enlisted but every American man and woman between the ages of 17 and 70—and then some—has a solemn duty to do everything in his or her power to win the war, and I am of the opinion that it is much more important to write today, not about the better blast furnaces, but about more and more blast furnaces and how soon they can be completed so as to increase, as rapidly as possible, the production of pig iron to replace steel scrap that we have exported to Japan during the past few years and to make more steel which now must be made entirely out of increased pig iron production.

Our average steel ingot production in the past 5 yrs. has been 52,000,000 net tons and as the production during 1940 was 67,000,000 tons, a large amount of which went into munitions for the Allies, it is evident that the average production of steel ingots for the 4 yrs. preceding 1940 was less than 49,000,000 tons.

Steel Ingot Output

The steel ingot production for 1941 will be between 82,000,000 and 83,000,000 net tons and deducting the previous 4-yr. average of 49,000,000 tons we have had available for all war purposes 33,000,000 tons without reducing our domestic consumption below that average but with the reduction in domestic consumption with which we are all more or less familiar it seems quite likely that more than 33,000,000 tons has been used for munitions, the building of munition and airplane plants, etc.

As our Government has not made available any figures as to the amount of steel which has been used during 1941 for preparedness, Lend-Lease and Victory purposes and as it has not released any information as to the prospective requirements for these purposes during 1942, one would find it necessary to guess at these figures in order to make any prediction and all calculations based on such guesses would, of course, be entirely futile.

On account of the shortage of steel scrap for 1942 it is evident that the ingot production for that year will be somewhat less than for 1941 unless greater quantities of purchased scrap are made available and unless the existing blast furnaces can be so operated as to increase the output per furnace as realized for 1941. We hope that both of these objectives may be fully realized and that the production for 1942 may exceed that for 1941.

Pig Iron in 1942

With the blast furnaces now building and some tonnage from those scheduled, pig iron production for 1943 should be approximately 64,000,000 tons and if the purchased scrap available for 1943 is 21,000,000 tons, the steel ingot production for 1943 should be approximately 86,000,000 tons and if by reason of raising the ceiling on heavy melting scrap and the paying of a bonus for the delivery of remote scrap, automobile scrap and alley scrap more than 21,000,000 tons of purchased scrap were available, then the ingot production for 1943 will be correspondingly higher.

It is evident that the steel production must be increased to keep step with the mounting demands of our Victory program and, as pig iron production holds a key position, it is readily understood that pig iron producing capacity must be increased and if additional blast furnaces are to be finished two years from 1941, something drastic must be done about this matter immediately.

Standardized Furnaces

Evidently time is the essence of this whole matter and as a serious loss of time will be unavoidable if all of these furnaces are tailor-made to the personal desires of the engineers and operators of each plant, it would seem the part of wisdom to insist that these blast furnaces be not tailor-made but that they be standardized and the same general drawings and all details should be used on each furnace of approximately the same size just as far as possible.

It seems reasonable to expect that if the best men available for this purpose would cooperate in the design of the best 1200-ton blast furnace that they can conceive, if the best fabricators of this kind of equipment should be given just the right materials just when they need them, and if the best field engineers and skilled mechanics should be assigned the job of erecting these furnaces, the pig iron producing capacity which could be installed in the next 2 yrs. would be most gratifying to all of our people.

I hope that the above observations about blast furnaces—HOW MANY? HOW SOON? AND HOW? may be of interest to you and to your readers.

ARTHUR G. MCKEE

Steelmaking

by FRANK T. SISCO

Secretary Metals Divisions, A.I.M.E.

DURING THE PAST YEAR, and for the next several years while Uncle Sam is fighting to destroy totalitarianism, the emphasis in steelmaking has been, and will continue to be, on increased production. This clearly indicates that extraordinary steps will have to be taken not only to construct additional melting capacity but also to increase output from existing furnaces, to decrease the time per heat, and to increase the number of heats on a lining and roof.

It also means that many plants may be forced to make drastic changes in melting practice quickly, as either pig iron or scrap becomes temporarily short. It also means that a careful study of operating conditions must be made constantly to reduce consumption of manganese and other steelmaking alloying elements as these become temporarily or permanently scarce. It also means that more consideration than in the past must be given to the amount of tramp elements in the scrap; for nickel, copper, chromium, and others the amount present adventitiously should be known accurately so that in the manufacture of low-alloy steels no more of these elements than is absolutely necessary has to be added, and so that in the case of arsenic, tin, and other supposedly harmful tramps, the effect of the amount present can be judged.

The Refractories Problem

Larger heats, larger ladles, and less time for heats have compelled considerable attention to the life of refractories. There seems to be no marked tendency to use thicker open-hearth roofs; in fact some plants are using slightly thinner roofs with success. Owing to good cooperation by plant masons, repairs have generally been speeded up and roof life is no longer a bottleneck.

Pouring an open-hearth heat of steel into ingot molds. (Courtesy: Republic Steel Corp.)

There has been little change in checker construction; the tendency is to let well enough alone despite the fact that changing fuels and varying amounts and quality of scrap have caused difficulty. Some plants have opened up checkers even at the expense of heating surface but this has not been general.

Discussion of the refractories problem at the last open-hearth conference of the American Institute of Mining and Metallurgical Engineers brought out the fact that there is an increase in the substitution of basic front walls for silica brick walls and an increasing use of chromite-magnesite mixtures and other new bottom-making materials. Considerable interest was shown at this meeting in the Radex (chromite-magnesite) and Crespi dolomite refractories which have been developed and widely used in Europe in the past few years.

In the Crespi method powdered calcined dolomite of suitable composition and controlled particle size is fused into a homogeneous bottom without the aid of tar or other fluxing agent. Dolomite from the eastern United States is apparently adequate. The Crespi bottom is said to have an insulating value three times as great as that of sintered magnesite and a high resistance to slag penetration. It is also claimed that high-grade steels melted on this bottom are cleaner than those made on the usual magnesite bottom. Crespi bottoms have undergone rather thorough testing in a large electric furnace plant in this country.

In contrast to the first world war when the steel industry of the United States was handicapped because of its dependency on Austrian magnesite, we are now practically independent of foreign supplies, owing to the large-scale development, in the past 20 yrs., of the Washington deposits. Chromite of refractory grade is, however, practically all imported. Fortunately it is likely that the Cuban deposits, which are more suitable for refractories than for making ferrochromium, will be sufficient to prevent serious shortage, provided enough shipping is available. The solution of the problem of how the open-hearth and electric furnace plants can obtain an adequate supply of suitable refractories lies primarily in increasing the output of the refractories manufacturers, and this seems to be well taken care of for the present.

Manganese Supplies

In the last war, a shortage of ferromanganese was the steelmaker's chief problem. Despite the large expansion of ingot production in 1941, an ample supply of ferromanganese was available; before long, however, this condition may change, and the Government and the steelmakers are giving considerable thought to conservation. For an ingot production of 80 million tons, 1.5 million tons of manganese ore are needed, practically all of which must be imported, mostly from sources of supply where sea lanes are long and readily cut.

The most obvious method of conserving manganese is to reduce the amount used. A 5-point decrease in the average manganese content of all steel will save 2 to 3 per cent of the total amount needed. It has, therefore, been suggested several times that the required amount in most steel—namely, 0.60 to 0.90 per cent—be reduced to 0.40 to 0.60 per cent. It is, of course, easy to recommend that this be done; actually to do it is not so simple. Customers ordinarily have more-or-less rigid requirements for surface quality. Since for most steels there is a relatively delicate balance between manganese content and increased rolling difficulties, conditioning costs, and scrap loss, reducing the manganese would in most cases increase cost materially unless consumers would be less insistent on a high-quality surface.

Another difficulty in conserving manganese lies in the present strength requirements for steel to be welded. In such steel more than 0.25 per cent carbon is usually prohibited; hence, about the only method the steelmaker has for meeting strength requirements is to add comparatively high manganese. Considerable manganese could be saved if the strength requirements for these steels were lowered 4,000 or 5,000 lbs. per sq. in.

The possibility of conserving manganese by using spiegel or silico-spiegel is well known; also well known are the limitations in such conservation. Owing to the low manganese, the high ratio of carbon to manganese, and to the high phosphorus in much spiegel and silico-spiegel, especially in those made from domestic ores, these alloys cannot be used in steels that must be low in carbon or phosphorus; and uniformly high bath temperatures must be maintained to melt the necessary large additions of these low-manganese alloys.

It is, of course, a major problem to conserve manganese in rimming steels for sheet and strip, in which the manganese loss may be as much as 25 per cent, without lowering the quality of the product. This problem has apparently been attacked with considerable success in Germany. According to a report made to the last open-hearth conference, (Open-hearth Proceedings, A.I.M.E., Vol. 24, 1941, pp. 75-79) the Germans have reduced manganese losses from about 25 per cent to 3 to 6 per cent by changing the method of tapping. Working on the known principle that the best method of preventing excessive foam on a glass of beer is to tilt the glass and to let the beer run down the side, the ladle is tilted for tapping. As the ladle fills, it is turned gradually until it is in normal position. According to the German work, this method of tapping greatly reduces the amount of air entrapped in the metal and also the oxidation of manganese and carbon.

The Scrap Situation

Although there were a few shut-downs in 1941

caused by shortage of scrap, none of these was as serious as they may become in 1942. Of the 65,000,000 tons of scrap that will be needed in 1942 for a production of 90,000,000 tons of ingots and 25,000,000 tons of castings at least 35,000,000 will have to be purchased on the open market. It is difficult to see where that much scrap will come from, even if prices are raised, especially since few machines, automobiles, and other metal products will be scrapped during the next year or two if they can possibly be kept in service. There is only one answer to the problem of scrap shortage: Make synthetic scrap by the Bessemer process, provided pig iron is available, or increase the amount of pig iron in the average open-hearth charge. Neither of these possibilities will solve the problem permanently.

Automatic Open-hearth Control

Among the methods being studied, which in 1941 have already given indications of improving the efficiency of open-hearth operation either in increasing production or in reducing costs, are flame radiation and the use of automatic furnace controls. The latter has received considerable attention, and in a number of plants full- or semi-automatic control has been installed for fuel-air ratio, furnace pressures, roof temperatures, and reversals. Although automatic control has not been used long enough to give a final picture of its relative advantages and disadvantages, in general, reduced fuel consumption and increased output in tons per hour are clearly indicated. A good summary of the present status of automatic control has been published recently in the *Proceedings* of the Open-Hearth Conference referred to above.

The Status of Slag Control

At a time when the steelmakers' efforts are directed primarily toward increased production, it is surprising that much attention is also being paid to improving quality through slag control. It has been found, however, that slag control does not only improve quality and thus increase production through reduced rejects and increased yields, but it also lowers costs appreciably by reducing the amount of slag-making materials, by cutting the working time of the heat, and by increasing uniformity of practice from heat to heat. In many heats it also saves manganese.

In most large open-hearth plants, slag control is commonly used for killed and semi-killed steels, and in some plants it is used for rimming steels as well. Lime-silica ratios depend, of course, on the raw materials available for the charge, but are usually 2.3 minimum for low-carbon killed steel, 2.5 for higher carbon killed steel, and 2.3 to 2.6 for semi-killed material. If slag control is used for rimming steels, the ratio is 2.5 minimum.

It is generally agreed that slag control improves deoxidation practice materially and, if high-phosphorus iron must be used, it is also an important factor in making steels for which composition requirements are close. Despite the urge for increased production, slag control will probably continue to be essential in the open-hearth practice of 1942.

Open-hearth Shell Steel

Although there are differences in minor details, most shell steel is melted from a charge of about 45 per cent good scrap, 45 per cent hot metal, and 10 per cent limestone. The average carbon content when the heat is melted is 0.70 to 1.00 per cent, which is ored down to around 0.60 per cent. The slag is then shaped up and the carbon is blocked by the addition of silico-manganese and spiegel plus, in some cases, ferrosilicon or a small addition of aluminum to the bath. The ladle additions for a heat of about 100 tons are 1000 lb. of 50 per cent ferrosilicon and 75 and 100 lb. of aluminum. Ferromanganese may be added if necessary depending on the amount required, which is 1.10 to 1.40 per cent for the 0.38 to 0.43 per cent C grade, and 0.70 to 0.80 per cent for the 0.50 to 0.55 per cent C grade. Some shells are made from S.A.E. X1340 which contains 0.35 to 0.45 per cent C, 1.35 to 1.65 per cent Mn., and 0.075 to 0.150 per cent S.

Finishing slags have a lime-silica ratio of 2.2 to 2.6 (2.5 to 2.6 being commonly used) and contain 12 to 15 per cent FeO. Although grain size is usually not specified, some plants make heats with a relatively coarse grain—to improve machinability. No additions are made to the molds. The heat is poured into 24 x 24 or 22 x 25 in. big-end-up ingots weighing about 10,000 lbs. which are held 1.5 hrs. in the mold before being stripped. Fracture tests are taken from the rolled rounds representing top, middle, and bottom of the first, middle, and last ingots.

Bessemer Steelmaking

Recent interest in the Bessemer process has been partly economic and partly metallurgical; economic, because with a severe shortage of scrap suitable for open-hearth operation, and an ample supply of molten pig iron, first-class synthetic scrap can be made cheaply by the Bessemer process and is being so made and used today.

The metallurgical interest has centered around the use of the photoelectric cell in following the progress of the Bessemer blow and in giving exact data on the endpoint and on the afterblow. This work, which was done at the Jones and Laughlin Steel Corp., has all been reported recently to the Iron and Steel Division, A.I.M.E. Data secured with the photoelectric cell have been very helpful not only in

locating the endpoint of the blow precisely but also in correlating the length of the afterblow with the quality of the steel. Information secured by the photoelectric cell probably will also be helpful in controlling nitrogen, which has long been held responsible for embrittlement on cold working, for blue brittleness, and for strain-aging phenomena in Bessemer steel.

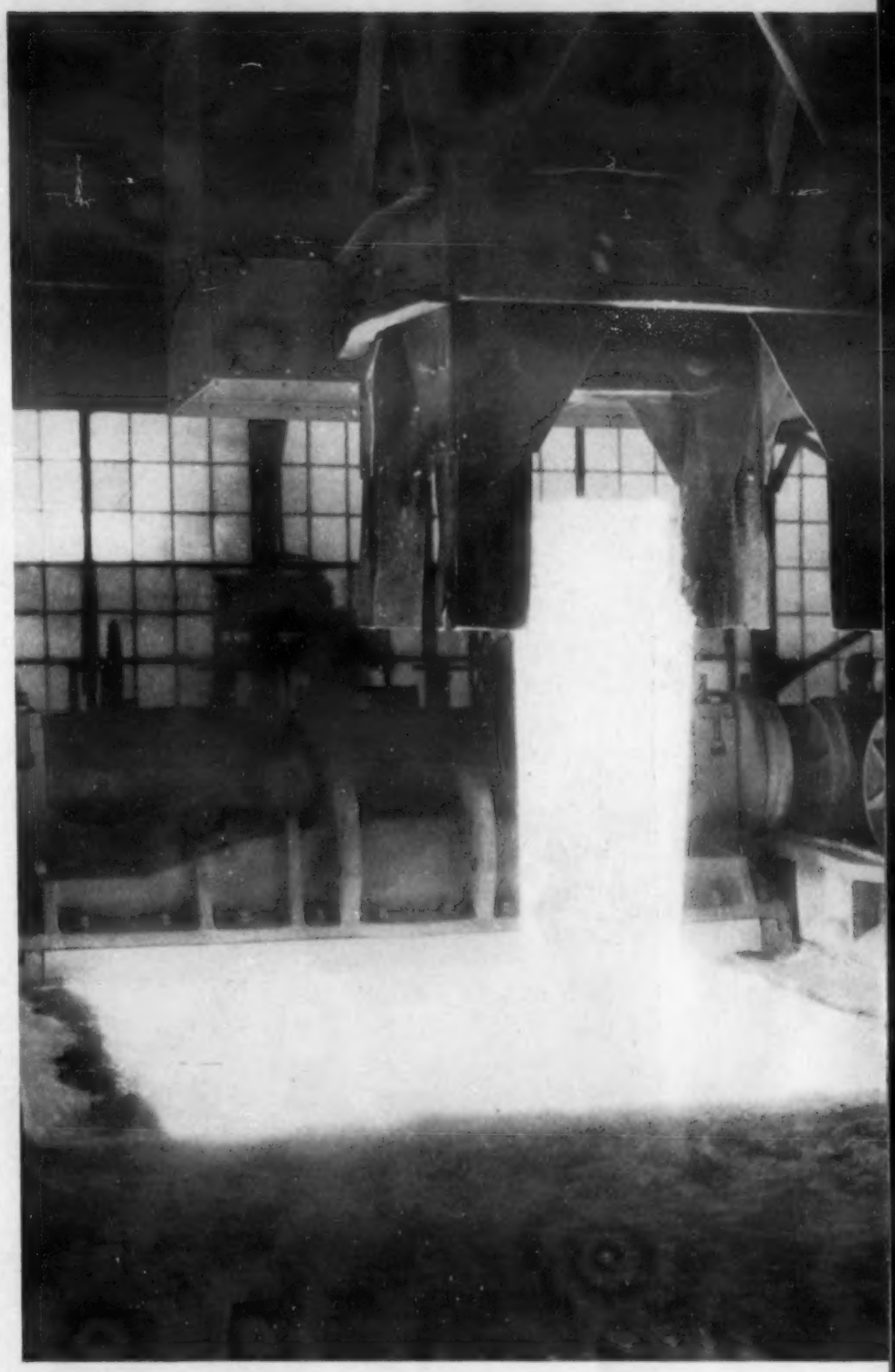
Electric Furnace Steel

Perhaps the most significant development of the year in electric furnace steelmaking is the heavy expansion in tonnage. A major reason for this somewhat disproportionate expansion is that the quality of electric furnace steel most readily meets war production requirements—particularly the "aircraft quality" standards—with considerable operating versatility.

Generally speaking, the trends have been toward bigger furnaces, higher roofs, more power and heavier charge for a given diameter shell. In processing, attention has been paid to obtaining a good oxidizing condition at first and then conditioning the slag.

Practice has had to be modified in many cases to accommodate composition changes impelled by raw-material stringencies or by the need to secure special technical properties. A major factor here has been the disciplinary effect on steelmaking control of ultimate Magnaflux inspection, which is rapidly growing in use.

A relatively unfamiliar stainless analysis with which some electric steelmakers are now working on a commercial scale is the high-manganese austenitic steel of the 18 Cr, 4 Ni and 4 per cent Mn type. There has also been growing preoccupation in electric furnace plants with high-strength stainless steels of the 16 Cr, 2 per cent Ni type for aircraft work. A very large increase in demand has developed for 25 Cr, 20 per cent Ni stainless steel for welding rod used in welding other special steels.



Removing a steel ingot from a soaking pit. (Courtesy: Timken Roller Bearing Co.)

Other Engineering Developments

Probably of equal importance but of less "news" value have been countless "changes in degree" that have occurred throughout the field of steel manufacture, particularly in rolling, forging, reheating, normalizing and annealing, tinplate handling, etc.

For example, many steel plants during the past year have gone heavily into shell-forging. One of the major trends of these times is the forging of shells to much closer dimensions than was once thought possible. Obviously when the shell cavity can be forged (rather than machined) almost to finished dimensions, much saving in machining time, machines and material results.

The tremendously increased production of molybdenum high speed tool steels has led to the necessity of more careful control of decarburization in mill-processing of such steels.

Restrictions on the use of tin have speeded up the acceptance and manufacture of electrolytic tinplate, which requires much less tin to be pore-free than does hot-dipped.

The conversion of continuous sheet mills to the manufacture of the more urgently needed plate for ships has introduced a host of new problems for metallurgical engineers. And decidedly worthy of mention is the still-continuing shortage of hammer-cogging capacity, owing to the heavily increased production of highly alloyed tool and stainless steels.

Coiling and shearing aluminum sheet. (Courtesy: Aluminum Co. of America.)

Non-Ferrous Metals

by GEORGE L. CRAIG

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WITHIN THE YEAR the metal industries, like many others, have experienced one of the most trying periods wherein they have been called upon to perform the tremendous task of conserving a long list of critical elements which in the past have been available and considered essential for the diversified needs of industry. In many divisions of the metal industries, particularly in copper and its alloys, it has been necessary, under present conditions, to make a relatively few alloys serve the applications formerly requiring literally hundreds of different mixtures considered standard by fabricators and consumers. These many readjustments have not materially altered fabricating practice. A tremendous demand for defense products has been made upon the fabricating industry and, although mill operations in many cases have been simplified, nevertheless fabricating facilities are being taxed to the utmost to meet the requirements of the War Program.

Advances in the fabrication of non-ferrous metals and alloys in recent months have been characterized by normal progress rather than by any sensational developments. The age old alloys, together with the somewhat newer alloys of the age hardening type, have been improved and their fields of application widened by the introduction of new types of processing equipment.

The smelting and refining branches of the industry have been called upon not only for an all-out production of base metals, but these metals, in their various shapes, must meet the more exacting specifications required by the quality conscious fabricating

and consuming branches. Developments have been mainly in a direction of larger units without material changes in flow sheets.

The use of water cooling for molds is being used commercially in a larger number of diversified applications with the resulting improvement in the physical characteristics of the castings. Melting and casting technique has been the subject of much recent study and, as a result, better control of atmospheres, reduction in metal losses and a general improvement in the physical characteristics of castings has occurred.

Continuous Casting

Continuous production methods are being applied in practically all branches of the industry. Although the art of continuous casting of metals is still in its infancy, remarkable progress has been made in the direction of producing sheet, rod and tubes by various processes under commercial conditions. The direct production of semi-fabricated shapes eliminates many intermediate operations which are time consuming, thus reducing the introduction of defects through numerous handlings. Direct rolling processes for the production of basic shapes, although these, broadly speaking, are still in the development stage, are being operated commercially on aluminum, copper and lead alloys with speeds of conversion that were considered impossible only a few years ago.

The so-called extrusion casting processes continue to play an increasingly important role by delivering semi-finished shapes which are readily converted into the finished product without producing scrap of any consequence.

It is not within the scope of this summary to make specific reference to the advances that have been made in annealing and heat-treating procedures, but great strides have been made by the introduction of modern continuous controlled atmosphere furnaces. Batch methods of treatment have almost entirely disappeared. The accurate control of temperature and atmosphere is responsible in a large degree to the improvement and uniformity of all products requiring such treatment.

Surface Characteristics

It has long been recognized that it was possible to develop methods, other than chemical, to impart to the surface characteristics of fabricated materials properties which would render them particularly adaptable to applications requiring the production of surface films capable of withstanding certain corrosive conditions. Controlled atmosphere furnaces have made it possible to produce thin, resistant surface films on numerous alloys. It has likewise been recognized that chemical films produced by electrochemical or contact procedures impart unusual characteristics to the surface properties of fabricated products. Many of our commercial alloys form highly refractory scales on heat treatment, and considerable progress has been made on the use of chemical solutions, other than the conventional, that have been considered standard for many years.

The joining of alloys continues to receive considerable attention. Progress has not only mastered the simplification of repair procedure, but through the handling of long, continuous lengths of metal, has reduced materially the time of the fabricating cycle by eliminating frequent threading of machines.

Tube Mills

Many new installations have been made to increase the capacities of the tube mills, nearly all of which have recognized the advantages to be gained by the extrusion process. The so-called refractory alloys, which previously created many fabricating problems, are now handled without difficulty. The manufacture of composite tubes and sheets as well have presented certain problems, but these have gradually been eliminated by the introduction of modern extrusion drawing and rolling equipment. Numerous combinations have been made available in composite tubes and, with the increased use of this type of composite, improvements in methods of production may be expected.

Metal Powder Products

Metal composites, produced from a variety of powdered non-ferrous metals and alloys and by electroplating processes of one description or another, are consuming increasing quantities for the production of numerous intricate shapes that were formerly cast or processed from semi-fabricated products. Spectacular developments are occurring daily in this field, and with the developments that have been made in processes, it is now possible to produce articles with almost any degree of density required by the application. Metal composites run the entire gamut from high density impervious sections to highly porous plates and tubes required in a variety of filtering applications. The size and range of properties obtainable in such composites are constantly increasing with the application of larger presses and a better knowledge of the technique of sintering and compacting in improved controlled atmosphere furnaces.

It is regrettable that many of the new advances in fabricating procedure that have been developed by the necessity of the Defense and War Programs must be omitted from this discussion. For obvious reasons it is permissible to deal only with generalities, and the result may appear to be only a progress report on the state of affairs in the non-ferrous fabricating industry.

Foundry Operations

by EDWIN F. CONE

THIS REVIEW OF METALLURGICAL ENGINEERING developments in the gray iron, steel, malleable and non-ferrous foundry industries is based on facts and opinions obtained from several authorities in each industry. They were asked for data and information which, in their opinion and experience, were most instrumental in shaping the past, the present and the future of these industries. Their response has been both valuable and whole-hearted and their cordial cooperation is fully appreciated and acknowledged.

Gray Iron Castings

Fluctuations in composition of gray iron which follow the course of melting heterogeneous material in the cupola have been a problem for some time. Several methods have been adopted to overcome this, with the object of obtaining better mixing of the iron before it enters the ladle.

One of these is the enlarging of the well of the cupola so that it serves more as a reservoir for holding considerable quantities and the cupola is never completely drained until the end of the heat. Another practice is to use a forehearth. Foundries which are called upon to manufacture iron within close limits of composition have been and are more successful after adopting such practices. This has been forced to some extent by the tightening of specifications and the urge to produce better iron.

Applications of instrumentation to the cupola are in the early stages. In the past year, however, considerable interest has been shown in regulating the cupola by better control of air supply and by conditioning the air. More uniform melting and more uniformity in the product are pointed to as results. This development will probably broaden in the near future.

The use of complex ladle treatment alloys is reported by one authority as having been greatly extended in the past year. Such treatments have been used for some time to modify the properties of gray cast irons, but it was not until recent years that their value was generally appreciated—they are now being employed in routine production quite extensively. Quoting this authority:

> Not all irons require treatment, some of them do not respond; nevertheless there are others where the treatment is remarkably effective with the result that the increase in tonnage of irons treated has been steady. It is necessary to use only small quantities of ladle alloys, quantities which are insufficient to change appreciably the composition of the iron. A small amount of ferrosilicon added to the ladle, for example, may effectively reduce chill and improve the strength of the iron out of all proportion to the amount of silicon added. Some foundries have found it possible to reduce the silicon content of their irons by using ladle treatments and thus help in conserving our silicon supply. One trend in modern ladle treatment alloys is to compound them from graphitizing or carbide stabilizing elements.

Improvement of cast irons by heat treatment continues. This trend is indicated by the application of flame hardening to lathe beds and the extension of this feature to alloy rolls. The application of induction heating to the hardening of airplane cylinder liners is outstanding and likely to be extended.

The alloying of cast irons has steadily increased, though its more rapid expansion has been interfered with by priorities in certain metals and the finding of substitutes. As to high strength cast irons, these are receiving general acceptance—they are being used in applications formerly closed to gray iron. Foundries are now giving more attention to plain cast iron and its possibilities in seeking ways to reduce alloy content. Close attention to details in their manufacture has produced gratifying results.

One authority expresses the opinion that very little progress can be expected along refinements of cast iron, except through the use of auxiliary melting units. Duplexing, etc., improves control where the production and quality required are great enough to justify installation of the necessary auxiliary equipment. Cast iron production as a rule consists of a metal melting and mixing metallurgy rather than chemical refinement. This procedure may introduce impurities under present conditions. But the use of desulphurizers improves in importance.

A technical development of importance is the introduction of tellurium as an alloy in gray and white irons. It is the most potent chill producing element known today. In the past year comparatively large quantities of chilled castings were poured from iron to which minute quantities of tellurium were added.

Steel Castings

The most outstanding development in steel castings is the "belated but broad recognition that steel castings, as materials of engineering construction, have genuine merits of their own." No longer are they generally regarded, as in the recent past, as a more convenient or cheaper but less desirable substitute for rolled products or forgings. Witness the use of castings in crank and camshafts and more recently in gears. Now comes the rapidly expand-

ing use of cast steel armor, shells, bombs and gun mounts—"little short of a revolution."

The production of cast armor parts of greater size, weight and intricacy is one of the noteworthy developments in the last 12 to 18 months. This has made possible the elimination of riveted joints, a fact of the greatest importance in the serviceability of the equipment. Armor plate castings are meeting the ballistic requirements of wrought plate.

The experience gained from the heat treatment of armor plate castings and other intricate parts is predicted as having a profound effect on the methods used in the next 10 yrs. in the making of cast parts for normal peace-time uses. "In particular the prejudices that have so long existed against heat treatments of heavy castings, involving rapid cooling from heat treatment temperatures, will undoubtedly completely disappear. The object lessons in increased strength and toughness, produced by such treatments, and the lack of the difficulties, so long considered inseparable from the practice, will be an overwhelming argument against the fears of our most conservative engineers." Liberalizing the requirements of various specifications will be one result of this development.

The use of X-ray testing in general and particularly the new million-volt machine, has played and is now playing a large part in developing the technique of making large complicated castings and their acceptance for critical engineering and other uses. Such tests can now be made in a fraction of the time formerly required. The development of equipment of increased size and power is bound to increase the volume of information leading to thoroughly sound castings. Radiographic examination of steel castings is being given considerable study and thought by nearly all steel foundries in the country.

Scarcity of certain steel-making alloys has forced the substitution of other compositions. But metal compositions have been carefully studied. In such changes as have been made, both in composition and heat treatment, no compromise in the mechanical properties has been involved.

A continuing trend toward combining the founder's and the welder's arts in the production of engineering structures is emphasized. To an increasing extent, castings are being adopted as parts of welded assemblies in which rolled or forged members and castings are used. Difficulties formerly encountered in the manufacture of complete castings for the part desired are in this way eliminated. At the same time the expense and waste involved in making up complicated assemblies out of a multitude of small

Pouring a 130,400-lb. cast iron turbine base from 5 ladles simultaneously. (Courtesy: Westinghouse Electric & Mfg. Co.)

parts of rolled steel is avoided. This commentator suggests that it may be necessary to invent a new name for the shop that is neither a foundry nor a weldery, but a combination of the two.

At least 20 new electric furnaces were purchased last year for steel foundries but the expansion in 1942 is expected to be on a larger scale. There has also been a larger demand for the side-blow converter.

Malleable Iron Castings

A trend in the malleable iron castings field which has continued and expanded is duplex melting—cupola-air furnace or cupola-electric furnace. This type of melting permits mechanized molding because it provides continuous melting, and therefore expanded and speedier production—an essential in any war program. The use of less pig iron is pointed to as another advantage.

In heat treatment, more radiant tube, controlled atmosphere annealing furnaces are being used now, resulting in a shorter annealing cycle and a more uniform product.

Interest in the pearlitic types of malleable iron has expanded. This is a product of higher yield strength, ultimate strength and hardness than regular malleable iron, though its ductility, measured by percentage of elongation, is reduced. In its production the radiant tube, controlled atmosphere annealing furnaces, alluded to above, are used to produce these types of malleable iron.

A technical development which in the opinion of one authority seems to promise interesting possibilities is the addition of tellurium plus a graphitization accelerator in order to make possible a decrease in annealing time.

A development that is felt to be outstanding has been and is the increasingly important place that malleable iron is occupying in the Defense and War Program. This was fully discussed in a paper by J. H. Lansing before the American Foundrymen's Association last May. Both regular malleable and pearlitic malleable castings are entering into the construction of standard scout cars, in Army mechanized equipment as steering gears, axles, motor supports, in firing equipment, and so on.

Considerable interest has developed and expanded in the flame hardening of malleable and in the induction hardening of pearlitic malleable iron.

In these days of a shortage of steel foundry and rolled steel capacity, engineers responsible for the design of defense material should look into the possibility of using malleable and pearlitic malleable castings, says one authority. In many cases such castings will be found entirely satisfactory for the job. Some work has already been done along this line during the past year but there is room for considerably more.

Cupola malleable is also considered good enough for many uses.

Non-Ferrous Castings

The Defense and then the War Programs have given rise to many changes in the non-ferrous foundry industry, particularly as regards the character of the output.

There has been a tremendous increase in the volume of magnesium and aluminum castings, particularly for aircraft. A foundry technique for magnesium alloy castings has been developed and improved, and the engineering applications broadened.

Many have been the troubles which have beset a number of brass and bronze foundries in getting supplies of copper, zinc, tin, etc., or in using unfamiliar scrap in place of the virgin metals.

In die castings the use of a lead base as a substitute for zinc is the outstanding development.

Two developments in the use of special molds deserve mention. The casting in plaster-of-Paris molds of certain non-ferrous alloys in the relatively low-melting class is expanding. This is pointed to as permitting the casting of intricate airplane motor parts and others to correct size, eliminating the need of a surface finish. The casting in heat-resisting rubber molds of such low-melting alloys as white metal (tin or lead base) is a recent trend.

One commentator states that there have been some quite recent and significant trends in specification writing. The promotion of simplification, coordination, correlation and the like in consumer-producer relations means greater speed in this war emergency. One object of a specification is to obtain a product suitable for the services intended. Many existing specifications are not so effective nor so economical for the purpose as might be desired. Coordinated specifications, streamlined, and which also insure quality, will save a great deal of confusion, red tape, delay and loss of time of executives, workmen and testing engineers.

In the field of recently published technical papers, it is pointed out that in general these have not been up to high quality standards and that those published in this country have lagged behind the actual state of the art. This is believed to be particularly true of the bronzes. There is need for more extensive published researches on bronzes and other cast non-ferrous alloys or for more research, or both.

A development which appears to one authority to have definite commercial applications is ductile high tin bronze. The British Admiralty is much interested in it for condenser tubes in place of cupro-nickel. Castings of 10 per cent Sn bronze with an elongation of 60 to 65 per cent are obtainable by using an oxidizing flux which prevents hydrogen absorption by the bath and by using directionally controlled cooling of the cast product.

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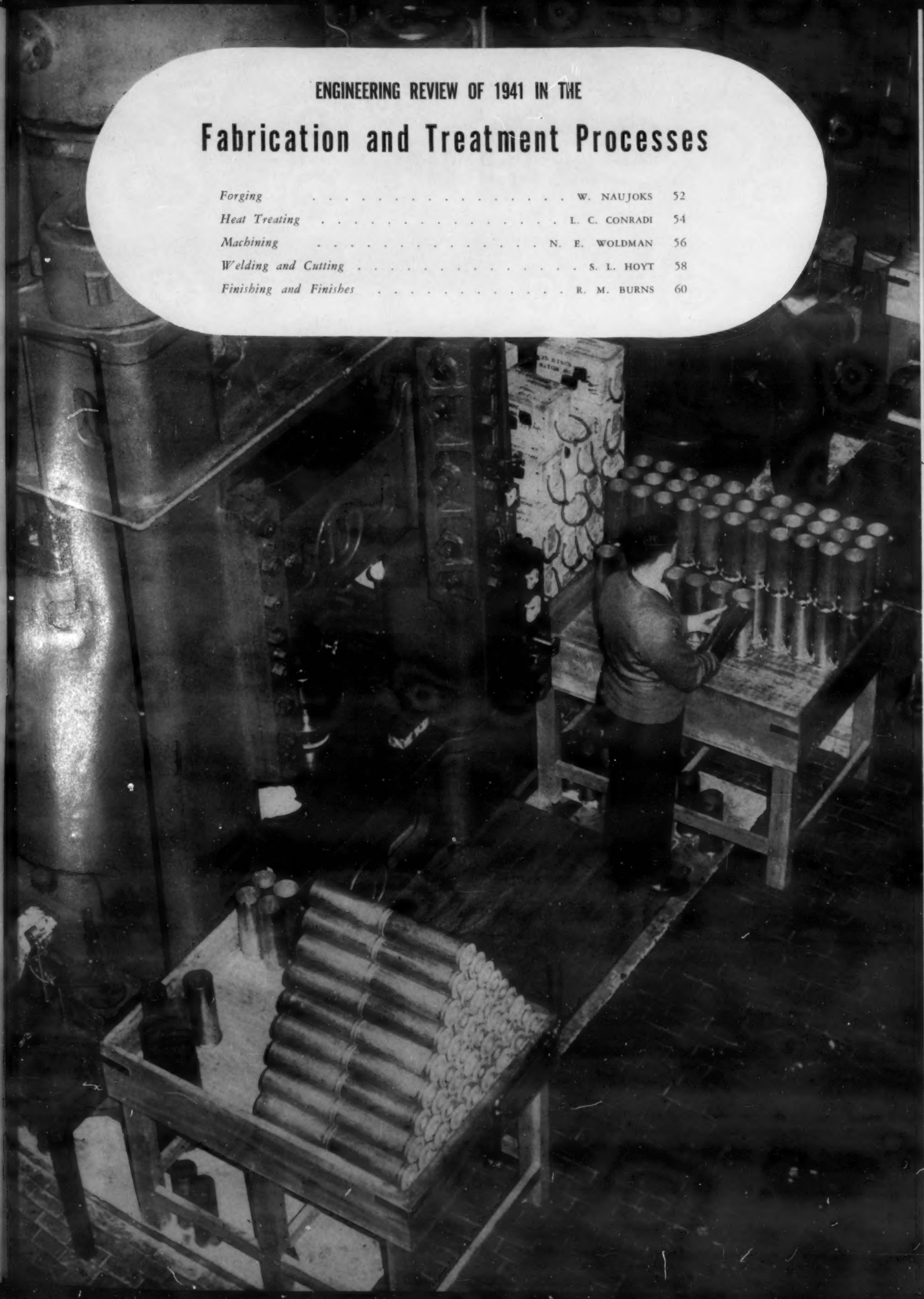
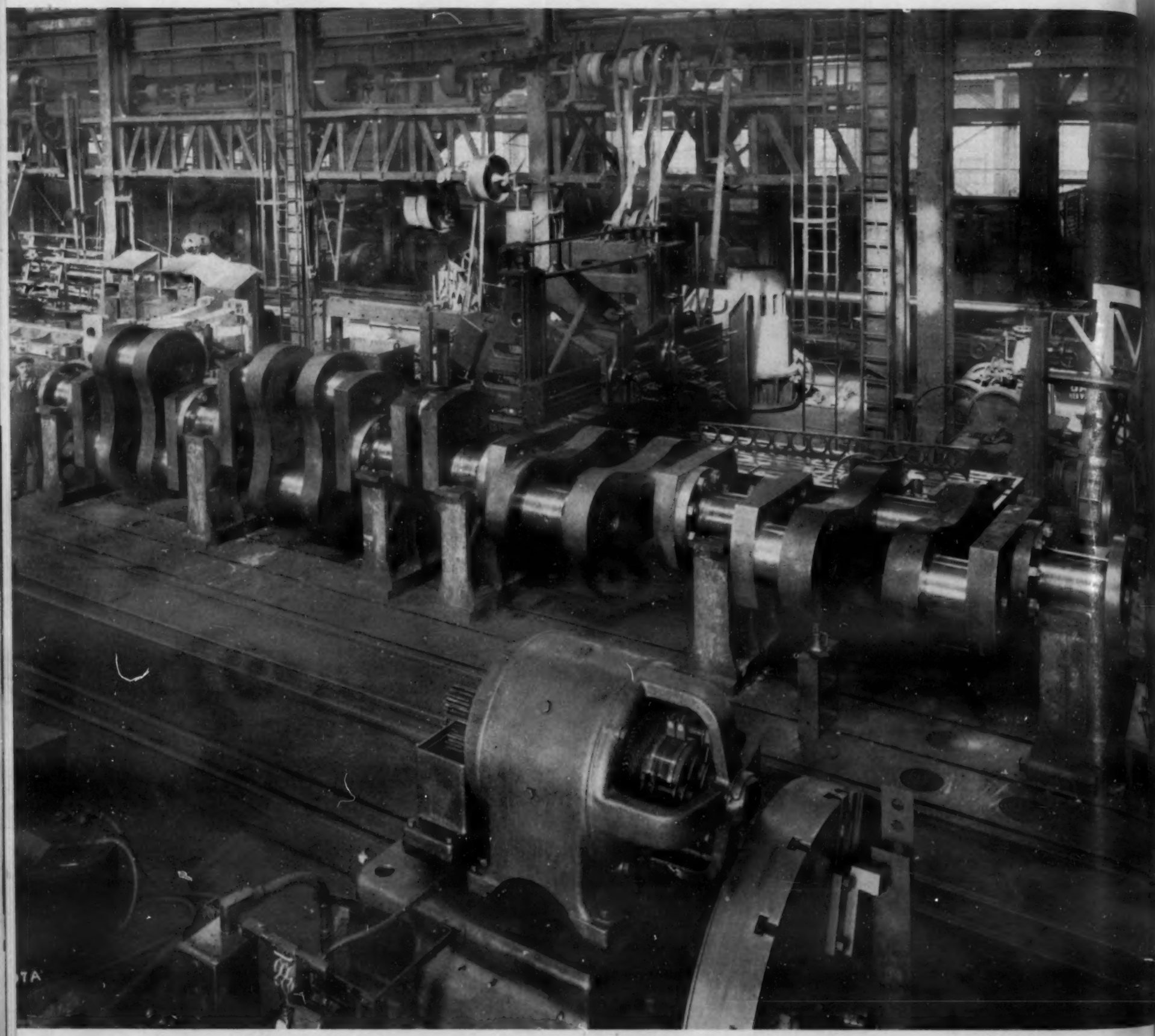


Forging

A large crankshaft made up of several steel forgings. (Courtesy: Bethlehem Steel Co.)



by WALDEMAR NAUJOKS

Chief Engineer, The Steel Improvement & Forge Co., Cleveland

THE PROGRESS OF ANY INDUSTRY is not marked by any definite lines over a given period of time and any developments are the result of constant study and work. The character of the problems confronting an industry depends upon the particular era and its demands, and today we are faced with an "all-out" program of production to preserve the democratic way of living. This program began about 18 or 20 months ago and the events of the past weeks have increased its tempo to a marked degree.

National emergency conditions just past and the war conditions of the present have removed normal and orderly developments of engineering and metallurgical problems and thrust upon the forging industry, along with other industries, greater problems to be solved in a much shorter period of time than previously given. This has placed a heavier burden upon executives, engineers, metallurgists, and others down the line.

Quality on a Production Basis

The big demand has been for the highest quality forgings on a production basis, to be used for aircraft parts and similar exacting purposes. In the normal course of events, it was possible for the few forging plants specializing in aircraft quality forgings to supply the demand because the production of such parts was relatively small as compared to production quantities of forgings of a less exacting nature. To meet the unforeseen demand increase, it has been necessary for engineers and metallurgists to develop production methods in testing and checking to keep apace with the increased forging production.

The high standard of quality required for aircraft, and for naval and army ordnance forgings to withstand the severe wear and strains imposed upon them, has tended to emphasize the importance of fibre structure in steels, the importance of design, and the importance of heating and heat treating in the processing of forgings. Aircraft forgings in particular, where maximum strength with minimum weight is desirable, include in their design the direction of grain flow in order to obtain the maximum benefits of the metals being used. This, in turn, necessitated the development of special forging technique to accomplish the results incorporated in the design. Forging steps are changed, or added, to produce the part without forging defects and this includes the rupturing of the fibre structure during the forging operations. Thin flat sections, high ribs, and abrupt changes in sections must be watched in particular.

Quality forging stock is the basic prerequisite to high quality forgings and the inspection of forging bars and billets has tended to become more rigid. Close control of chemical composition, freedom from segregation, flakes, and dendritic structure are required. Closer observance of the surface condition of forging stock has been the tendency, particularly on alloy steels where exacting rolling practice is essential to quality. Some of the highly alloyed steels have all of the desirable qualities of strength to severe loads but they are sensitive to heating and heat-treating conditions and close control is mandatory to obtain the desired results.

Forge Heating and Heat Treatment

The importance of good heat conditions for forge heating and the heat treating of forgings cannot be over-emphasized. Wherever possible, the heated atmosphere must be neutral to the steel being heated to prevent undue surface decarburization. On forgings with large thin sections that are not subsequently machined, surface decarburization is an important consideration. Uniformity of structure and hardness, particularly on forgings with heavy sections, is essential.

Recently-installed fuel-fired and electric furnaces for heating and heat treating forgings have been carefully designed with these factors in mind. Atmosphere control is increasingly applied and modern furnace construction is fast approaching the ideal of rapid but thorough and uniform heating, without "burning" the work—all this, too, in the face of increased capacity requirements.

An important development in recent months has been the application of electric salt bath furnaces to the heating of ordnance forgings. For example, in one shop very rapid heating of 155-mm. shell forgings, for nosing, is being accomplished in large electric salt bath units without scaling or decarburization and at lower temperatures than was once thought possible.

High frequency induction heating has also been introduced or extended for the heating of shells for nosing, and there has been at least one important installation of high frequency furnaces used to heat shell-forging billets prior to upsetting. Direct resistance heating is also employed for a similar purpose.

And speaking of shell-forging, this is one operation that has grown in application beyond description during the past year. Various types of modern shell forging presses, mills and machines now manufactured by several companies permit the forging of internal shell cavities that require little or no machining and save materials, machines and valuable time.

The heat treatment of forgings seems to be reaching a peak. Once employed chiefly for normalizing and annealing, heat treatment has in recent years been broadly extended to include hardening and tempering of forgings. This trend has been accelerated by the development of modern alloys steels and high strength bronzes and by the application of stricter service requirements to forgings.

Heat Treating

By L. C. CONRADI

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DEVELOPMENTS IN HEAT TREATING, new types of furnaces and new methods for the ferrous and non-ferrous metals and alloys do not grow up over night, so to speak, ready to carry their full load on the production line the next day. The foundations and roots of any development which we may for convenience wish to assign to 1941 can in reality be traced back through 5 yrs. or more of research by the producer, the user or quite likely both. The management, the production, and the research divisions of alert and progressive metal using and metal producing industries are thoroughly aware of this fact. The developments of the present, thus, are but the markers along the road showing the trend and nature of future developments.

Control of Furnace Atmospheres

A scant 10 yrs. ago the control of the atmosphere in a furnace merely meant adjusting the gas or oil burners to produce an oxidizing or a reducing flame, or at most perhaps the introduction of an unburned gas into the muffle. Today the control of a furnace atmosphere is not so simple. We have learned more about the subject and now know that the prepared gas must be closely regulated with respect to its hydrogen, oxygen, carbon monoxide, carbon dioxide and water vapor content depending upon whether it is used for bright hardening, bright tempering or bright annealing. Fortunately with suitable furnace construction the desired atmospheric control can be obtained within the furnace muffle regardless of whether gas, oil or electricity is used as a source of heat.

The marked increase in the use of controlled atmospheres during 1941 in the batch types and in the continuous conveyor, walking beam, and pusher type furnaces is, of course, based upon sound economy. That is to say, bright annealing eliminates expensive pickling and abrasive cleaning operations. Likewise, the use of non-scaling and non-decarburizing atmospheres in hardening and tempering of carbon and alloy steels of all types eliminates costly grinding and metal finishing operations. In addition, better tool, die and part life is bound to result.

The very noticeable demand for bright tempering during 1941 is significant. It is no longer good practice to use a non-scaling and non-decarburizing atmosphere for bright hardening and then deliberately discolor and scale the parts in the ordinary recirculating air tempering furnace at temperatures up to 1000 or perhaps 1300 deg. F. A few bright tempering installations are in use and an increased interest of the user and the furnace manufacturer in this connection is very gratifying. The author recently was instrumental in specifying and selecting controlled atmospheric hardening and tempering equipment for the manufacture of 20 mm. anti-aircraft cannon.

Another interesting atmospheric controlled furnace installation with which the author was connected during 1941 really provided for a study of various atmospheres under large scale production conditions without interfering with the scheduled work output of the heat-treating department. In this installation, three types of gases, namely, "Drycolene," "Endogas," and ordinary reducing combusted gas, were each piped to a batch type electric tool hardening furnace, conveyor type electric annealing furnace, a conveyor electric brazing furnace, a conveyor electric bright hardening furnace and to the cooling units for gas carburized parts. By a mere turn of a 3-way valve anyone of the three gases was made available at any or all furnaces. Controlled atmosphere studies under such conditions will prove extremely valuable to the user as well as the builder of furnace equipment.

Carburizing

The trend for 1941, as for many years previous, has been toward gas carburizing using either a gas as such or resorting to cracking an oil in the retort. Both solid carburizer and gas carburizing have their

place in the economy of things. It so happens, however, that gas carburizing lends itself better to mass production at minimum labor, material and equipment cost and in addition permits very satisfactory type and depth of case control.

One of the outstanding developments during 1941 is the fact that parts can be gas carburized and cooled, ready for reheat hardening operations leaving the surface absolutely free from scale, decarburization and carbon smut deposits. Carbon smut is the bane of the plater because none of the pickling methods, regular, inhibited or anodic, nor any of the various alkaline and vapor degreasing methods will remove carbon smut. In order to obtain satisfactory adhesion of chromium or any other plate, the carbon smut must be removed. It can be removed by wire brushing but that is expensive and slow.

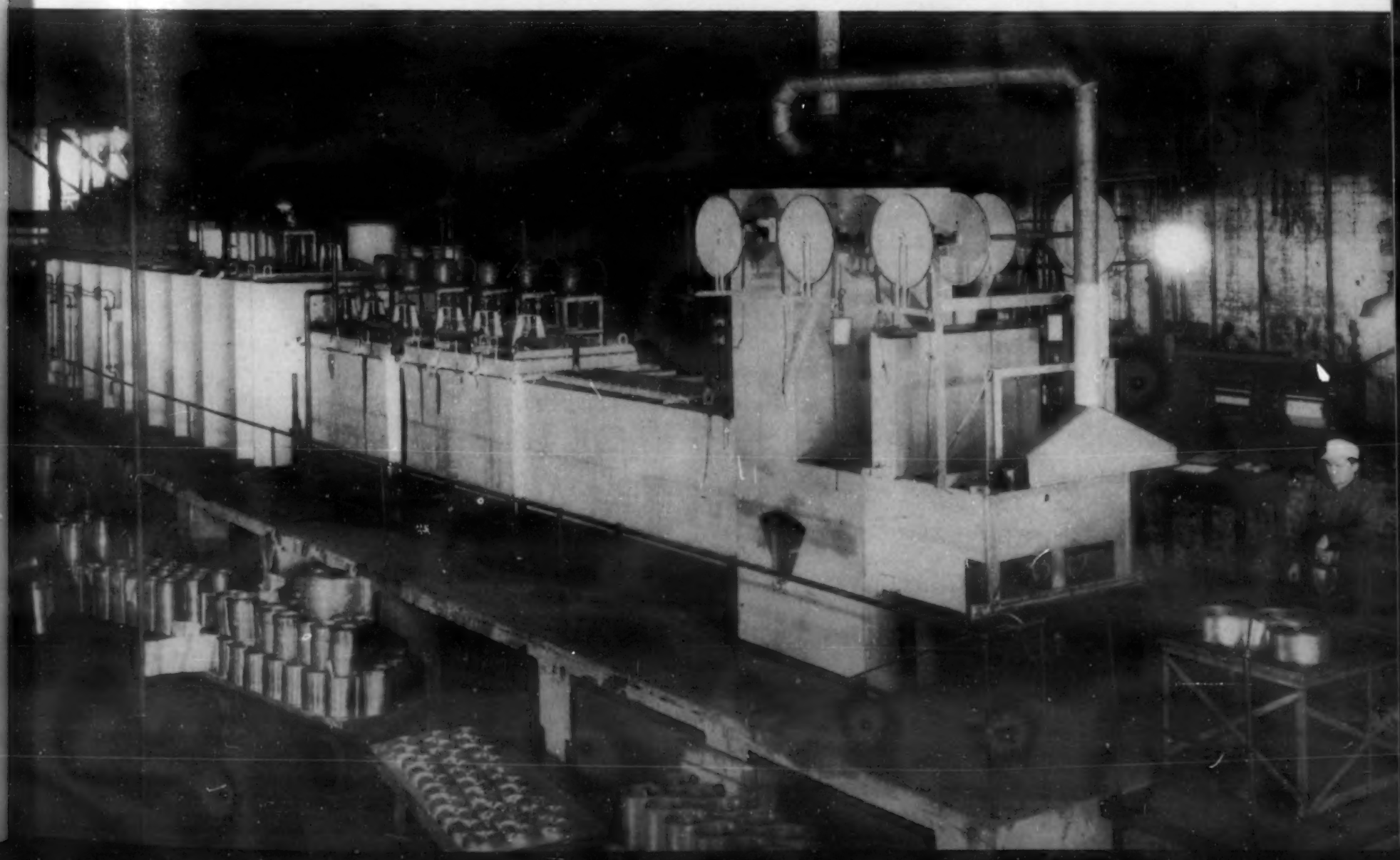
The combined efforts of the laboratory, heat-treating department and above all the genuine interest of the operator of the gas carburizing furnace solved this problem in an accounting machine industry with which the writer was connected. To obtain parts as bright as a new silver dollar, it was found necessary to regulate the amount of gas used during the carburizing cycle and to introduce city gas into the cooling unit immediately after the basket of carburized parts had been placed in there to cool down. Needless to say, it was necessary to thoroughly clean all parts by vapor degreasing before loading into the carburizing unit. Just an alkaline wash or a rinse in gasoline or other petroleum solvent was not satisfactory. The writer is firmly convinced that further studies will be made along this line by other interested parties. Making available the three types of prepared gases as mentioned above under control of furnace atmospheres was for the purpose of gathering more information along this line.

Induction Heating and Salt Baths

Heat treatment by induction made its first real impact upon industry about three or four years ago. Since then its application has spread rapidly. As a source of high frequency current the motor generator, the spark gap converter, and the vacuum tube are rapidly finding the particular field for which they are best adapted. The writer's observations of the behavior of several 1 kw vacuum tube sets for the heat treatment of small accounting machine parts indicates that this type will probably be built up to 5 kw capacity in the next year or so. Both the vacuum tube type and the motor generator type are good for continuous operation in their respective fields of application. The spark gap type seems to fill an intermediate field for intermittent operation.

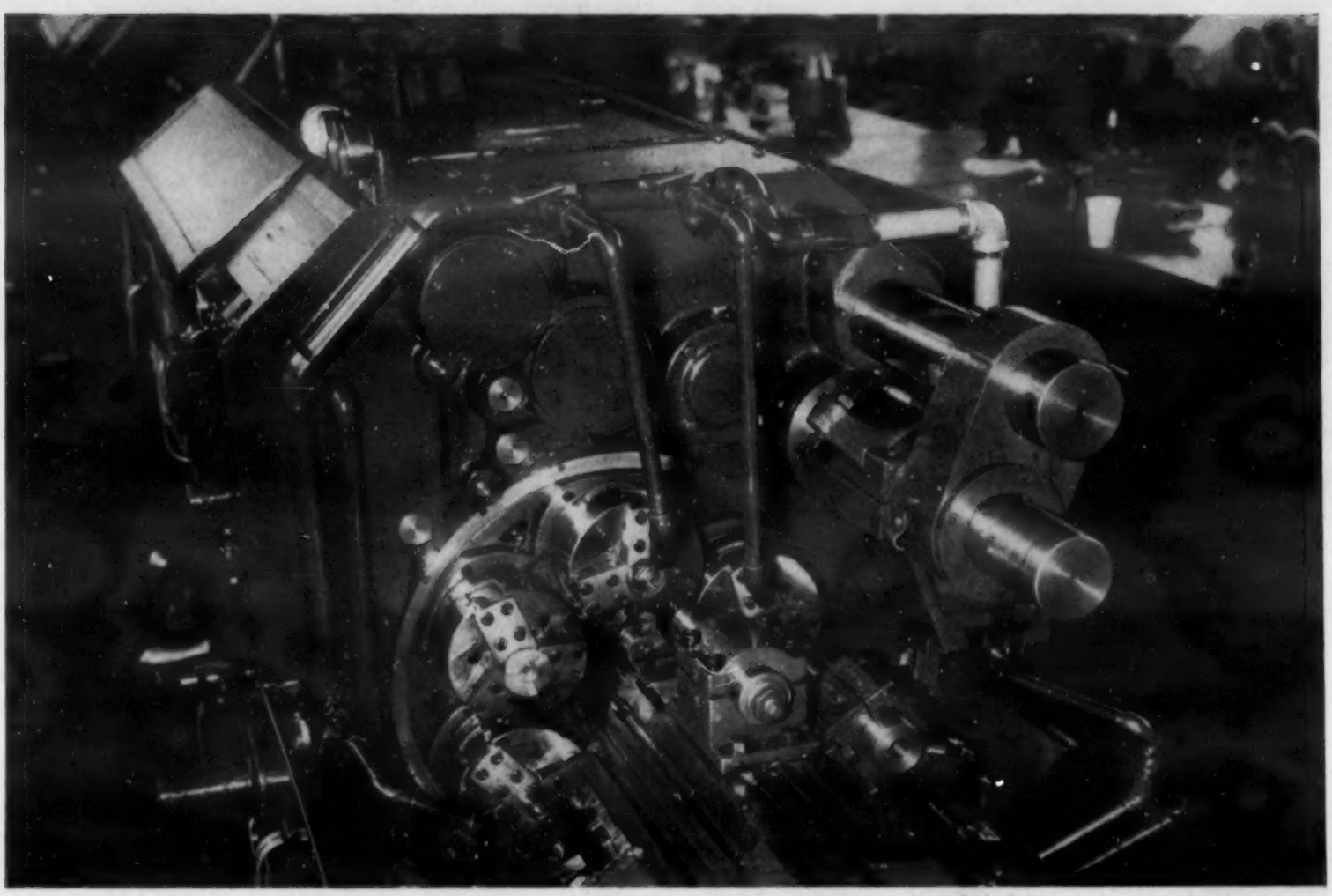
There does not seem to have been any significant development in salt baths using either neutral or activated salts. They are, of course, being built larger every year to suit new applications and the use of internal electrodes as a source of electric heat continues to be favored over other methods of heating. Perhaps as a new development during the past year it might be mentioned that brazing and hardening is now accomplished in one operation.

A large furnace for heat treating stock for automotive radiators.



Machining

A six-spindle chucking machine for turning out engine jaws of forged alloy steel.



by NORMAN E. WOLDMAN

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THE APPARENT SHORTAGE in tungsten during the latter half of 1941 and the curtailment by the Office of Production Management of the production of high tungsten high speed tool steels has compelled the machine shops and manufacturers to adopt the hitherto much avoided molybdenum types of high speed steels. This type of cutting tool steel was not in favor since most heat treaters lacked knowledge of the technique of properly hardening the alloys without obtaining soft skins. Today the molybdenum type cutting tools are winning popular acclaim because of advances in heat-treating practice.

Molybdenum High Speed Steel

There are many grades of molybdenum type of high speed steels on the market. They have been divided into five types, depending on their composition. Each type has found its own field of usefulness, and, if carefully selected and properly applied, will be found just as efficient a cutting tool as the high tungsten type of high speed steel. The non-cobalt type is very effective for rough cuts, but is not quite as satisfactory for very light cuts. The cobalt type of molybdenum high speed steel makes an excellent tool for light and finish cuts. Therefore, as our knowledge of and experience with molybdenum high speed steels increases, the applications will multiply and, as a result, we will not feel the tungsten shortage as much as we do now.

A new development which will greatly decrease the loss of tungsten high speed steel tool bits in the machine shop is the brazing of the bits to steel shanks. During the past, when the tool bits became too short to be held in the clamps, they were discarded and resold as scrap. Today, we find that the tool bits brazed to the steel shanks can be reground to the very end with negligible loss.

Increased production has meant increased use of the sintered carbide type of tools in spite of their

high cost. Greater use of carbide cutting tools meant augmented production, improved quality and longer tool life. High rigid requirements on surface finish for aircraft engine and aircraft accessory parts called for greater use of carbide tools. The necessary higher speeds and even greater feeds resulted in greater output.

Automatic Machines

The year 1941 saw a great impetus in production of raw material and finished products for national defense. Increased production of finished products brought development and more extensive use of semi-automatic and automatic machines for continuous in-line production.

One of these automatic machines for increased production is the multiple six and eight spindle Bullard Mult-Au-Matic vertical lathes. A battery of these machines is used for machining alloy steel forgings such as flywheels and gear blanks for aircraft starters. These machines operate as many as 23 tools simultaneously on seven forgings at a time but still require only a single operator per machine.

Single spindle automatic machines for roughing out parts have been replaced with multi-spindle automatics; namely, four, six and eight spindle machines. Six spindle automatics are also used for similar jobs. The six spindle chucking machines resemble the six spindle automatics except for the necessity of hand chucking each part. These chucks, however, as do many on the other machines, operate rapidly by means of compressed air.

The new Foster turret lathe is a type of semi-automatic machine for the machining of large alloy steel forgings. Here again the individual forgings have to be chucked by hand. These machines are capable of rough and finish machining the forgings and generally contain from 10 to 17 tools in a set-up. Two of these turret lathes can be operated by one man. The machine runs automatically after it is once set up. The operator places the rough forgings in the machine, removes the finish machined parts, and in his spare time, inspects the finished pieces.

Gear Shaving and Drill Presses

Gear shaving machines have been developed for the main purpose of increased accuracy of the surface of a gear tooth. In other machines, two gear cutting operations frequently have been required to give the desired accuracy and finish on a gear tooth. Now instead of the second cutting operation, the gear is shaved, thereby giving not only the accurate dimensions but a nicely polished surface as well. In addition, the shaving operation is much more rapid than the gear cutting operation, resulting in increased rate of production. Designs of these gear shavers differ considerably. One type is a flat plate on which the shaving teeth are mounted and over which the gear is rolled. Another type is that of a circular cutter, very much like a gear itself, and this is run in mesh with the gear being shaved. Steel gears with hardness values as high as 40 R_c can be shaved.

The introduction of the multiple spindle drill presses has aided in stepping up production. These presses contain a multiple of drills properly located in fixtures for simultaneous drilling of many holes through the one face. The automatic multiple spindle drill press is unique in that the drills go into the work for a certain depth, then release and rise to clear the chips, and then drill into the work again. This is repeated over and over again automatically until the holes are properly drilled.

Another improvement is the two and four spindle lathe for boring. The boring tool can produce grinding finishes and can hold tolerances as close as 0.0003 in. It can also be used to bore from both directions into a long hole since the spindles are opposite each other and travel toward each other on the lathe bed. This feature is important when two holes must be bored in opposite sides of a part and the holes must have a center line in parallel. The two tools eliminate the necessity of changing the set-up to bore the opposite holes.

Grinding and Other Machines

New thread grinding machines have eliminated the soft skin due to decarburization and the distorted thread obtained in heat treatment of alloy steel screws, bolts and studs after machining or chasing. These machines are being used for grinding threads on hardened blanks with great accuracy and high surface finish. The thread grinders generally use a large grinding wheel, quite thin and tapered to a sharp edge. The part being ground is held between centers and threaded past the rapidly moving grinding wheel which cuts the teeth first to a rough size and then, on threading back, gives it a finish cut. Some of the machines are equipped with small grinding wheels to cut internal threads. A recent development on these machines is a device to automatically dress the grinding wheel.

One of the most recent developments in gear cutting has been the new Zerol gear cutting machine. This unit cuts a type of gear with a curved tooth for bevel gears. The cutter is a circular cutter and, because of its rapidly moving surface, is able to cut teeth much more rapidly than the generating type of gear cutter.

Other new developments and improvements on machine tools have been made and will continue to be made to increase machining towards greater production. The year 1941 has seen many new and interesting advances. We all expect still greater advances in 1942.

Welding and Cutting

by S. L. HOYT

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THE FEATURE OF THE HISTORY of welding in the past year was the big expansion in its use and the corresponding achievements in terms of increased productive capacity of industry. While a large amount of steel is used in the form of single piece castings, forgings, and the like, and another large amount is riveted for fabrication or erection, nearly one-half of all the steel made was welded, according to one authority.

Another important development was the extension of welding to many of the non-ferrous metals and alloys and to the stronger steels containing higher percentages of carbon or alloys, sufficient to exert a marked strengthening effect. While it is highly desirable to be able to fabricate these materials by welding, numerous new problems were introduced for the welder, the engineer, the metallurgist, and the user. These problems, as they arise, are attacked by the research engineer whose guidance is needed for sound progress in these new fields.

Hence we may record as a third significant development the greatly increased activity of such agencies as the Welding Research Committee, etc. Finally, we may mention the increased attention paid by the producers to the control of composition and quality of materials used in welding. Thus the major developments of 1941 were a large scale swing to welding as a fabricating process and increased study of all the details which make for its successful use.

In Shipbuilding

Coming to the individual applications in which this movement has been noteworthy, no place has welding shown to better advantage than in the ship building industry. Ever since steel ships have been made, the individual plates and sections have been joined by riveting. Riveting gave an outward appearance of strength and on the high seas the popping of rivet heads seemed to indicate some sort of security in the ability of the ship's structure to withstand buffeting. This has been practically all eliminated in the present ship building program and the first all-welded cargo ship was built in 1941. Great credit goes to the American Bureau of Ships and the Maritime Commission for their active and intelligent cooperation. Not only does welding greatly speed up the construction but it saves a large amount of weight and improves the performance of the ship.

This swing to welding in ship construction was probably the outstanding feature of 1941. Welding opens the way to pre-fabrication of parts of the ship's structure and the production of the shipyard proper is very effectively supplemented in this way. According to the Maritime Commission a ship will be built in 5 mos. instead of 6 mos. required by riveted construction, and in their 705 ship program a saving of 500,000 tons of steel will be effected. Since this weight is utilized in carrying capacity, these ships will be able to carry a half a million tons extra cargo per trip.

So far the steel used is largely mild steel plate, though it seems likely that steels of the low alloy class will ultimately be used in an important way for this application. The use of welding for the fabrication of other large equipment such as freight cars, passenger cars, truck bodies and the like might also be mentioned, though this was a somewhat earlier development. The past year has witnessed an extension of welding in these fields and the conversion of old shops or the erection of new shops to take full advantage of the new methods has materially speeded up production.

In Aircraft

In the field of aircraft manufacture, first the defense program and now the war program called for a tremendous expansion in production. This involves several methods of welding, particularly arc and gas welding steel tubing and spot welding aluminum and aluminum alloys. While riveting still is an important method of joining aircraft sheet and other parts, spot welding is rapidly proving its capacities in this field too. Large scale studies have been made of equipment, timing, pressures, and the like since success depends on the accurate maintenance of the optimum welding conditions. In this connection there is considerable interest in stored energy systems because a heavy current can be applied for a very short period of time.

Another new system is that which produces a pulsating effect, made possible by the new control devices. Aircraft tubing has been gas welded for many years. The security of this type of welding in the hands of a skilled welder was important, but the limitations due to speed has produced a shift to metallic arc welding which was particularly pronounced in the last year. A shift of this kind is not as simple as it may appear to be at first glance, and the designing engineer and the testing engineer have had to cooperate closely with the welder and the

metallurgist to maintain the high quality required by aircraft.

In aircraft arc welding, the development and use of auxiliary apparatus for crater control has been a feature, while the question of AC vs. DC welding has been revived in this field and at present, at least, there is renewed interest in the use of AC electrodes and AC welders.

In Ordnance, Tanks, Etc.

This same general swing to welding in 1941 has also improved the fabrication of ordnance, scout cars, tanks and the like, which is true even though the parts may be made of heat treatable steels. The same has been true of the production of machinery and, with some significant limitations, it holds for various engineering structures. Machinery that is fabricated in the shop is being made more and more

by welding. Here the problems are somewhat simplified for the introduction of welding, and more adequate control can be set up to produce satisfactory welds and adequate inspection is available to check the finished results. Progress in erecting many outdoor engineering structures has been much slower, in spite of the favorable experience in ship building. This seems to be due mainly to the necessity of welding in the field under many and varied conditions and in all positions and to lack of necessary engineering information on designs and uncertainty of the costs of welding.

In this same connection the welding of locomotive boilers seems to be still in the incubation or experimental period. This application of welding has been slower to mature than many others, for reasons that an outsider does not understand very easily, though it is reported that a trial unit has been authorized and is now being very carefully tested in operation. The difficulty seems to be due to uncertainty of the behavior of the shop-made joint when subjected to bending and fatiguing stresses in service.

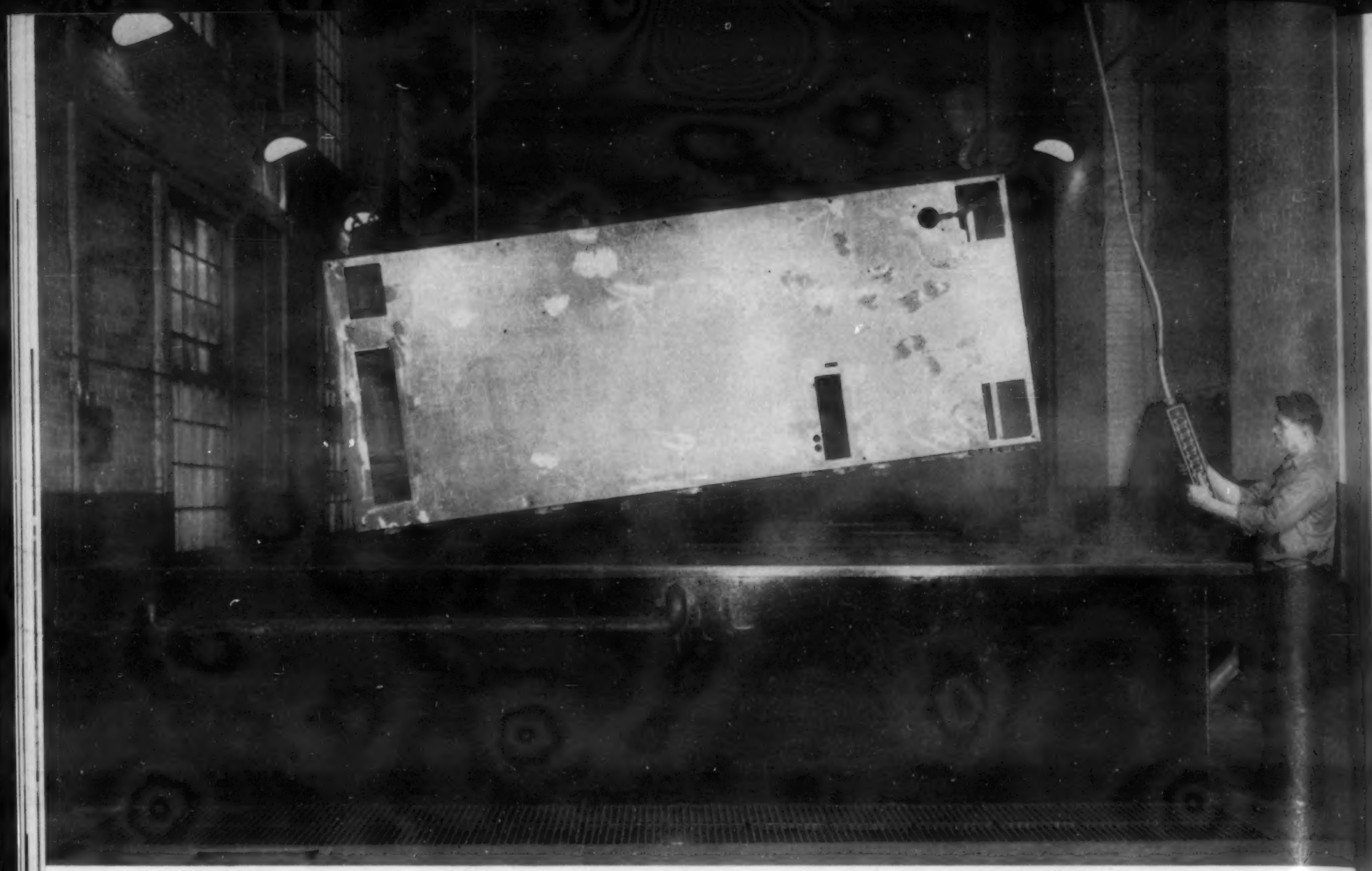
Though welding is usually thought of in terms of the finished part, it has also come to play an important role in the manufacture of semi-finished parts. One example was mentioned in connection with ship building. Another example is the present large use of welded pipe and tubing.

Cutting and Shaping

While publicity has usually been given to the electrical methods of welding, principally metallic arc welding, the consumption of gas for welding, gouging, cutting and shaping continues on a huge volume. Flame cutting has become a very valuable adjunct of the machine shop in preparing parts for welding. The versatility of gas in welding was again demonstrated by the development of the method of oxyacetylene pressure-welding with which process two rail ends or other similar objects may be joined.

To be fully useful, welding must be adequately implemented by machines to carry out the operations, instruments to control them, and inspection tests to check the finished product. The equipment manufacturers have held up their end in this field during 1941 with numerous contributions.

Research and development have been mentioned as necessary auxiliaries of the expansion of the welding art. On the opposite side we have the codification of welding practice and inspection methods which are designed to secure faithful performance in service. 1941 has seen an extension of these activities, including a serious attempt to unify and simplify the various codes.



Phosphate treatment of large welded enclosure. (Courtesy: Westinghouse Electric & Mfg. Co.)

Finishing and Finishes

by R. M. BURNS

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FINISHES AND FINISHING have been markedly affected by the defense program. Materials shortages have forced the development of new finishes and the modification of many widely used protective and decorative coatings. The enormously extended use of aluminum and magnesium alloys in aircraft, the construction of naval and merchant ships, tanks, and all sorts of military equipment, new factories and cantonments have all combined to make vast demands upon the production of protective finishes and finish materials.

Metallic finishes are playing an important part in the program of metal conservation. The more available material, steel, coated with copper-nickel-chromium or with copper alone, has been and is being widely substituted for aluminum, brass, bronze and nickel alloys. Zinc and tin electroplate are displacing hot-dipped coatings of the same metals with substantial reduction in metal consumption.[1]

Developments in commercial tinplate manufacture by hot-dipping methods during the past year have been limited largely to securing good tinplate on which there is a reduction of about 10 per cent in the quantity of tin used. Hot-dipped lead coatings, in some cases alloyed with tin, are being substituted very largely for hot galvanizing. Zinc coatings on wire and strip electroplated directly from purified solutions of zinc ores (Bethanizing) have increased in volume. The plating industry voluntarily reduced the consumption of nickel 50 per cent a month before priority control was established. A further reduction to 15 per cent has been required in non-defense applications. When defense uses are included, the total reduction of nickel employed in plating is approximately 75 per cent.

Sprayed metallic zinc coatings applied by either the wire (Schoop) process or the metal powder (Schori) method have met wider use as bases for

the anchorage of organic finishing systems on important steel structures under severely corrosive exposures.[27] Sprayed coatings of aluminum and aluminum with one per cent zinc have been applied to aircraft engine cylinders.[2] A new electric metal spraying gun and process was announced.[3]

Bright Plating

The use of bright plating became still more general throughout industry and additional plating bath compositions were developed for both zinc[4] and nickel.[5] The addition agents employed in the confusing multiplicity of bright nickel baths are of two distinct types[6]—(a) cobalt salts and aryl sulphonic acids, amides and imides which produce grain refinement, but not brightness, and (b) cadmium and zinc salts, sodium formate, aldehydes, ketones and amino poly aryl methanes which, when used together with the first class, produce brilliant and smooth plates.

High speed plating of zinc, nickel and tin was increased considerably in volume, particularly in continuous application to steel strip. This has been facilitated by developments in plating baths and processes and by apparatus improvements. Further experience with chloride type nickel plating baths indicates their suitability for rapid plating.[7] Electrotinning of steel strip is progressively displacing hot-dipping. The largest installation of this process[8] is now doubling its capacity. An acid stannous sulphate bath with phenolsulphonic acid addition agent is used and the line runs at 250 ft. per min. making strip tinplate having about 0.5 lb. of tin per base box coverage. Coatings down to 0.000003 in. thickness made by this process have proved suitable for cans used with dry contents. The desired bright lustre is obtained in this process by a mild scratchbrush method.[8a]

In another electrotin process now operated on a semi-commercial scale brightening of the deposit is obtained by passing through hot oil.[9] Immersion in a hot solution of citric acid, stannous chloride and hydrazine hydrochloride has been proposed as an effective method of brightening tin electrodeposits.[10] Still another electrotin process, not in commercial production, is said to permit higher speed plating than methods now in use.[11] Deposition of tin on thin steel strip at current densities of 1000 amp. per sq. ft. and higher are claimed to be possible using plating apparatus of a radically new design.[12] An advantageous feature of this equipment is the provision for plating on one side of the steel strip at a time, thus making it possible either to coat only one side or to deposit coatings of different thicknesses on the two sides. Dry electrical contacts with the strip are made and a rubber cushion is employed to prevent build-up of deposit at edges.

The widespread substitution of copper plating for 40-60 per cent of the thickness of nickel coatings has markedly increased the use of copper in coatings, although this use continues to be but a fraction of one per cent of the consumption of this metal. An additional bright copper bath has been proposed[13] and it has been shown that citrates could be substituted for Rochelle salt in the Rochelle salt-cyanide type of bath.[14]

Aluminum As A Coating

A new continuous hot-dipping process for coating steel strip or sheet with aluminum has been developed.[15] Processes for coating aluminum with practically any of the heavy metals, such as cadmium, zinc, tin, lead, and copper, have been developed in the laboratory and are expected to attain commercial scale production later.[16]

The production of fly screen coated by the corronizing process reached a volume of 4,000,000 sq. ft. per month.[17] This coating consists of a duplex layer of nickel and zinc heated to induce a certain amount of alloying.

Speculum or white bronze plating (approximately 40 per cent tin and 60 per cent copper) which has been in commercial use in England was introduced on a semi-commercial scale in this country and proposed as a substitute for nickel-chromium finishes.[9] It is similar in appearance to polished silver, does not tarnish appreciably, is corrosion resistant and between nickel and chromium in hardness. Similar in reflecting power and suitability for decorative coatings, but more expensive, is rhodium plating, the use of which has been somewhat further extended.[18]

Anodizing and Surface Coating

The vastly increased use of aluminum and magnesium has led to the more extensive application of anodizing and other surface conversion coatings for protection against mild exposures or as corrosion resistant bases for the anchorage of organic coatings to be used in severely corrosive environments. A new development still in the laboratory stage is the production of thicker aluminum anodized coatings in chromic acid.[20] These coatings can be dyed readily in pastel shades of an attractive non-metallic appearance, and seem to offer good corrosion protection. A process of producing a film over tinplate by immersing in hot alkaline phosphate solutions has shown promise for the prevention of sulphide staining on the interior of cans.[19]

Organic Coatings

New developments in organic coating materials have been required because of shortages of tung oil and certain solvents and restrictions upon non-defense uses of alkyd and phenol formaldehyde resins. Importation of tung oil has been restricted by the

Far Eastern crisis, while the increasing American production has not attained sufficient volume to afford much relief. The most suitable oil substitute for tung oil from the standpoint of drying characteristics has proved to be dehydrated castor oil obtained by a new process,[20] and its use has grown considerably. The drying properties of linseed oil have been improved by a process which increases the degree of unsaturation. Soy bean oil, which is rather slow drying and must be used in conjunction with other drying oils, has been used to considerable extent, but this product was increasingly diverted because of exportation as food. The acreage of soy and castor beans and flax was considerably expanded to keep pace with the drying oil demand.

A new resin, called Pentalyn, derived from rosin, was developed and found to be particularly suitable for varnishes since it produces rapid drying without the use of tung oil.[21] It is an abeitic ester of pentaerythritol. A new development of great promise was that of the Melamine resins[22] which cure at the unusually low baking temperature range of 175 to 200 deg. F. Coatings employing these resins or modifications of these resins obtained by combining them with urea or even alkyds, were found to possess superior hardness, abrasion and mar resistance and to show good color retention. Maleic resins obtained by the substitution of maleic anhydride for phthalic anhydride were used in increasing tonnage as hard alkydes in light colored decorative enamels, quick sanding lacquers and sanding sealers.[23]

Of outstanding importance among recent developments are the so-called "Carbic"[24] anhydride resins. "Carbic" anhydride has a molecular weight of 164 and melts at 161 to 163.5 deg. C. Like phthalic anhydride it may be reacted with glycerine or the glycols to give resins of the alkyd type. The rates of these reactions are faster and the resulting products, unlike the phthalic anhydride resins, are compatible with and react with fatty oils. "Carbic" glycerol resins, thus, may be combined with linseed and other drying oils directly.[25] "Carbic" anhydride is the basis of a versatile group of resins. One of the liquid types is heat reactive and air drying and is used for processing of oils and oil-resin combinations yielding products which may be used to replace tung oil in the formulation of fast drying high gloss enamels, and as a basis for many other types of finishing materials.

Pigments

In the pigment field the most striking development of the year was zinc tetroxy chromate [$ZnCrO_4 . 4Zn(OH)_2$] a definite compound possessing improved corrosion inhibitive properties combined with low rate of solubility in water.[26] It should find wide use in primer coatings for aluminum and magnesium alloys as well as for steel structures. Marked improvements were made in zinc yellows in the direction of improvement in nonchalking qualities. Zinc dust (metallic zinc powder) was employed to an increasing extent in primers and paint systems for steel and galvanized surfaces in atmospheric exposures. Practical tests and experience in the maintenance of underwater gates and steel structural parts of fresh water locks and dams were reported, and showed the favorable performance of finishes employing zinc dust and zinc oxide pigments and phenolic resin vehicles.[27] A new process for the production of titanium oxide has yielded a pigment of increased hiding power with less tendency toward chalking.[28]

Infrared or radiant heat was employed to a much larger extent for baking organic finishes.[29] The cost is primarily that of the electric power and the process has gained in favor as a method of increasing the rate of production. Modifications in formulation of finishing materials were found desirable to obtain the most satisfactory results.

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This page is dedicated to the 5-article symposium on "Recent Trends in the Metal-Design of Instruments of War" that until going-to-press time was scheduled to start here. The following articles, already prepared for this timely symposium, were either withdrawn or withheld by the Army and Navy after the Japanese attack on Pearl Harbor on December 7th caused official reconsideration of all such material for the technical press:

Ships, by Paul Ffield, Bethlehem Shipbuilding Corp.

Tanks, by Brig.-Gen. G. M. Barnes, Ordnance Dept., Washington, D. C.

Guns, by Lt.-Col. H. F. Safford, Watervliet Arsenal

Other Ordnance Products, by Maj. D. J. Martin, Ordnance Dept., Washington, D. C.

The fifth article, on airplanes and engines, did not require Army or Navy approval and is presented on the following pages.

Aircraft and Engines

by GEORGE F. TITTERTON

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Present-day aircraft are built largely of aluminum alloys with some alloy steels used for highly stressed parts. Owing to the shortage of these materials and the inability to obtain them in the desired forms, a number of optional materials have had to be employed. Furthermore, the enormous increase in the quantities of aircraft on order has in itself justified a change of material or processes to attain more rapid production. This development is now underway.

Aluminum Alloys in the Frame

The basic structural material used in aircraft is 24S-T aluminum alloy (4.5 Cu, 0.6 Mn, 1.5 per cent Mg—heat treated). It has a yield strength of over 40,000 lbs. per sq. in. and an ultimate tensile strength of over 60,000 lbs. per sq. in., and its weight (density) is approximately one-third that of steel. It is commercially procurable in sheet, bar, tubing, wire and extrusions. As a substitute for the more common (but now hard-to-get) extrusions, such as angles, channels and zees, sheet or strip material is frequently bent or drawn to the desired shape. To obtain a more compact structure, and to aid in fabricating sheet metal parts the annealed 24S-O material is frequently used, and heat treated after fabrication.

Aluminum alloy forgings are very generally used for moderately stressed fittings. 24S-T is not forgeable, so 17S-T (4 Cu, 0.5 Mn, 0.5 per cent Mg) is specified for forgings. This alloy is about 90 per cent as strong as 24S-T. In special cases where high strength is necessary, 14S-T (4.4 Cu, 0.8 Si, 0.8 Mn, 0.4 per cent Mg) forgings are used. This alloy has a yield strength of 50,000 lbs. per sq. in. Tank flanges and secondary parts are forged of 53S-T (1.3 Mg, 0.7 Si, 0.25 per cent Cr). This material welds excellently and has good corrosion resistance with moderate strength.

Aluminum alloy castings are employed for nonstructural parts of odd shape. Alloys No. 43 (5 per cent Si), 195 (4 per cent Cu) and 356 (7 Si, 0.3 per cent Mg) are the most commonly used. Die castings have been used infrequently in the past, owing to the small number of parts involved, although there is now a trend toward their increased use.

Because 24S-T alloy is not satisfactory for parts requiring deep drawing, excessive forming, or welding, 52S-¼H (2.5 Mg, 0.25 per cent Cr) is used for these purposes. 3S-½H (1.2 per cent Mn) is also used for such items as welded fuel and oil tanks. These materials do not have great strength but can be formed and welded readily.

Steels

Chromium-molybdenum steel (S.A.E. X4130—0.8-1.10 Cr, 0.20 per cent Mo) is widely used in aircraft construction. In tubular form, it is used for landing gears and engine mounts. The sheet material is used in the fabrication of highly stressed fittings. This material can be formed and welded without difficulty.

S.A.E. X4130 has good air hardening qualities after welding, and this characteristic was valuable when entire fuselages were welded of this material without any subsequent heat treatment. Nowadays, however, practically all chromium-molybdenum steel parts are normalized or heat treated to 125,000; 150,000 or 180,000 lbs. per sq. in.

Steel forgings are used very extensively. When the finished forging must be welded to another steel part, X4130 steel is specified as the forging material. Such forgings are normally small in cross-sectional area and no difficulty is experienced in heat treating to 180,000 lbs. per sq. in., if necessary. Larger forgings or those not requiring subsequent welding are manufactured of S.A.E. 4140, or X4340 (0.60-0.90 Cr, 1.75 Ni, 0.75 per cent Mo) steel. S.A.E. 4140 may be heat treated to 200,000 lbs. per sq. in. and S.A.E. X4340 to as high as 225,000 lbs. per sq. in.

A recent development in aircraft design is the use of steel castings made of S.A.E. 4140 steel. This very interesting trend has been forced by the shortage of machine tools and the limitations of steel forgings. In one instance known to the author, a steel forging required 100 machine hours whereas the equivalent casting could be machined in 6 hrs. Although this is an exceptional case, similar savings can be made in many of the complicated parts used in present-day airplanes. S.A.E. 4140 aircraft grade castings can be heat treated to 180,000-200,000 lbs. per sq. in. and have an elongation of over 5 per cent.

When steel castings are specified, it is customary to call for 100 per cent X-ray inspection. All steel parts, whether fabricated, forged or cast, are subjected to Magnaflux inspection to insure the absence of cracks. Frequently, X-ray inspection supersedes or supplements the Magnaflux inspection.

Deep drawing quality mild carbon steel is being adapted to many aircraft uses. The availability of the material and the ability to stamp it to finished shape are attractive in these days of shortages and high production. Some weight penalty is usually involved as compared to an equivalent aluminum alloy part, but this is not too critical since the extra strength is frequently required on the high-performance airplanes of today.

Stainless steel (18 and 8) has been used in the manufacture of all parts of an airplane. It is most commonly used (in the stabilized condition) for exhaust collectors, firewalls and scoops. It forms and welds very nicely.

Other Materials and Processes

Inconel and K Monel are used where non-magnetic or corrosion resisting qualities are important. Inconel is frequently used for windshield and canopy frames adjacent to the compass. Inconel can be readily formed and welded.

Magnesium alloys were just getting a foothold in airframe construction before the present crisis created an extreme shortage. These alloys were used for such purposes as seats, shelves and oil tanks.

The electric spot welding of aluminum alloys is one of the biggest developments of the past few years. This method of joining these alloys is often considerably cheaper and faster then riveting, and results in lower aerodynamic drag. Its use is increasing very rapidly at present.

Also, the arc welding of steel is rapidly replacing oxyacetylene torch welding. The ability to weld heavier sections and the increased speed and reliability of the arc weld are the main factors involved in this transition.

Aircraft Engines

Certain very recent trends in the metallurgical design of aircraft engines are worthy of special mention. Aluminum alloys have lost some ground here to magnesium alloys, although the relative supply situation in recent months has interfered with this trend. More steel is being used in engines, too, chiefly at the expense of aluminum alloys.

Cylinder heads are now almost exclusively aluminum alloy castings, No. 122 (10 Cu, 1.2 Fe, 0.2 per cent Mg) and 142 or "Y" alloy (4 Cu, 1.5 Mg, 2 per cent Ni) being most widely used. Some liquid-cooled heads are made of alloy 43 (5 per cent Si). The use of this alloy, heat treated (actually, overaged), is also favored by at least one engine manufacturer for small castings to be made in large numbers.

The largest aluminum alloy forging in the engine is the crankcase. Many crankcases, however, are now being made of steel, according to one engine-plant metallurgist, and because of the higher strength of the steel are actually lighter than when made of aluminum and give satisfactory service, particularly from the standpoint of fatigue resistance.

Run-of-the-engine gears are usually carburized alloy steel. Large gears are nitrided to keep distortion at a minimum, since nitriding temperatures are lower than carburizing. Growing in popularity as a "stop-off" during nitriding are tin coatings.

Some of the most interesting trends have been in the alloys used for exhaust valves. Many engineers are now standardizing on such alloy steels as 14 Cr, 14 per cent Ni stainless. The valve stem is hollow and contains liquid metallic sodium. Valve seats are chiefly "hard metals" like Stellite, although nickel-chromium alloy (80 Ni, 20 per cent Cr) welded-on facings are growing in use.

Some plants are now finishing cylinder assemblies by metal-spraying with molten aluminum instead of by aluminum-painting. The metal-spray not only resists sea-air corrosion better, but stands up longer against heat-scaling.

In all parts of an airplane—engine as well as airframe structure—the primary considerations in the choice of materials are a satisfactory strength/weight ratio, reliability, workability, and procurement. The industry is always on the lookout for new materials and processes to improve aircraft.

Alternate Materials in Product Design

—A SYMPOSIUM

In the field of product design there has been no influence in recent years to compare in sharpness or breadth with the impact of raw material stringencies in 1941. The "defense" emergency diverted increasing amounts of vital metals and alloys from non-defense manufacturing to feed the ever-growing raw-material appetite of armament production. Today, with the program one of "victory" rather than "defense," all metals are critical, and product design is a scramble for substitutes. Even in the manufacture of munitions there has been a trend toward the judicious use of alternate materials.

Information on substitutes is most urgently needed by manufacturers of such non-essential civilian goods as electrical appliances, radios, cheap jewelry and consumer hardware, many of whom are now faced with complete or partial shutdown because of raw material shortages. Also, the busy non-military but still essential industries such as heavy machinery, industrial equipment, power supplies, etc. can ease the strain on their own practice and improve the situation elsewhere by designing "down the scale"—away from the magnesium, aluminum and copper end of the list, and toward the slightly more plentiful steel, cast iron or certain plastics.

This symposium is intended to serve as a guide to such "down-the-scale" designing, by presenting a composite picture of replacement-design practices developed in recent months. It comprises 8 articles (with a special reference table accompanying the last article), as follows:

"The General Picture," by H. W. Gillett
"Automotive Products," by A. L. Boegehold
"Machine Tools," by Tell Berna
"Heavy Machinery," by H. L. Day
"Valves, Pipe and Fittings," by J. J. Kanter
"Electrical Products," by P. H. Brace
"Containers," by H. S. Van Vleet
"Household and Other Goods," by H. R. Clauser

*The ideas presented can be of the greatest help—*now, *in those plants that continue to operate; and* later, *when some of the less scarce materials again become available for general use.* —*The Editors.*

The General Picture

by H. W. Gillett

A year ago the word "substitute" was absent from technical and business publications. Slight stringency in supplies of some materials was appearing, but the thought of officialdom, of laymen, and of most technicians was directed toward increasing of domestic supplies and of importations to give enough for both "guns and butter." Even at the beginning of the work of O.P.M., the thoughts of conservation and substitution were directed chiefly to the obvious cases of importation over long sea lanes, i.e., to tin, manganese and chromium.

Private enterprise had appraised the situation in respect to these metals and had built up some approach to a stock-pile. But that, within a year, such a metal as lead would be distressingly scarce, would have been predicted by few, if any prophets.

Strategic and Essential Metals

In earlier plans of the Army and Navy, only those metals that came from far away sources were considered "strategic" and needing to be stock-piled if and when pacifist sentiment would permit such action and if and when Congress could be persuaded to make an appropriation. Scarcity of aluminum, magnesium, nickel, copper, zinc and lead, all produced at home or by neighbors in such profusion that active research and extensive advertising were being invoked to develop new uses, seemed most unlikely.

But the need for planes and more planes in modern warfare soon brought out the need of vastly expanded production of aluminum and magnesium and when guns and armor and the tools to make them began to be ordered, nickel began to be tight. As substitutes for nickel steels were sought, vanadium steels were turned to, and a shortage of vanadium soon impended. The cartridge brass requirements swallowed up vast amounts of copper and zinc. Lack of zinc led to increased use of lead, in die castings and other applications, sufficient to add a last straw to the camel's back to a lead shortage. Similar cases occurred again and again, like a regular house that Jack built. Many industries were found quite unprepared to make any replacement for their customary materials, or even to know how to skimp a bit and still make a useful product.

Outstanding among the exceptions was the high speed steel industry, where molybdenum was standing ready to fill the shoes of tungsten, thanks to extensive research that had been carried on even when the relative prices of the two metals were such as not to offer immediate economic advantage.

Two Outstanding Facts

Two very definite facts emerge from the experience of the past year. The first is that a relatively small stock-pile, whose existence, location and size is known (as contrasted with a scattered inventory) can act as a highly effective fly-wheel. Everyone was so alive to the tin situation that ordinary produce had led to accumulation of a very modest supply, yet sufficient so that this metal, perhaps the most crucial of our strategic needs, next to manganese, has required only relatively mild control.

The other outstanding fact is that it is only the past well-seasoned research and development work that can be counted upon to permit early use of a substitute. Contrast the lack of prior development of steel cartridge cases instead of brass, with the presence of prior development of molybdenum high speed steel. The exigencies of the situation will bring the steel cartridge case, and corresponding freeing of copper and zinc, which will in turn free other metals being used as alternatives, but quantity production is months away, indeed it will be fortunate if it can be recorded a year from now.

Seldom can as full substitution be made as is being made of molybdenum for tungsten; in general the problem has to be attacked by squeezing off a few not-so-essential industries and slow and partial substitution in the essential ones, to give a saving in several places of some fraction of a per cent of the total supply, to add up to enough to give some relief to the general situation. This is accompanied by dislocation of non-defense industries, unemployment and general difficulty. Determining whether the saving is feasible and at the same time worth the dislocation, requires an understanding of production technology and of practical economics not often combined in one administrator.

Attainable Savings and Substitutions

On the whole, O.P.M. has acted slowly, partly due to a cumbersome system, now being revised through trial and error, but largely in order to avoid injustice. Attainable savings and substitutions have been pretty well appraised and can be instituted at need, like cutting off tin for beer cans. How many of the analogous cases, such as paraffined paper instead of tin foil, calcium or silver to cut down the antimony requirements of storage batteries, and the like, will have to be resorted to in 1942 is not yet clear, but it is evident that no one today can count on an adequate supply of any raw material previously used. Hence, everyone is substitute-conscious, a vast change from the industrial psychology of a year ago.

All these shortages mean that weapons of all sorts are being made; they are a healthy sign for our overall economy, distasteful as they may be to particular industries and localities.

Perhaps the most encouraging sign is that military specifications for direct munitions, armor, projectiles and the like are no longer being taken as sacred. The question is now raised whether amounts of nickel, manganese and chromium, unnecessary when proper heat treatment is applied, are not being swallowed up in these applications.

The whole situation calls for continued study by each user of raw materials from the point of view of his own particular needs. Letting George do it doesn't insure that George will lick your problem.

When the smoke all clears away, many metals will have found new uses and lost old ones, but knowledge of the limitations and the usefulness of substitutes will remain, to be applied as economic conditions change. If the search for such knowledge is continued after the emergency, and if real stock-piles of metals and their ores are put in storage, we shall be better equipped for the next emergency than we were for this one.

Automotive Products

by A. L. Boegehold

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The advancing wave of metal restrictions in the past year has imposed upon the automobile industry a continuous series of readjustments in materials going into construction of the automobile. The unbreakable law governing all this shifting of materials

has been that durability and performance must not be sacrificed. One by one zinc, aluminum, nickel, copper, chromium, vanadium, and even iron and steel, have been placed on priority. Some of these metals have been greatly reduced in car construction but reducing the use of some metals, such as copper, iron and steel, could only be accomplished by reducing the number of cars built.

Saving Zinc and Aluminum

Large amounts of zinc have been saved by substituting steel, cast iron, and malleable iron for zinc base die castings. Instrument panels, seat adjuster handles, door strikes, body moldings, defroster nozzles, horn projectors, horns, steering wheel hubs and brackets, transmission covers, and so on, have been changed to steel stampings. Rear compartment hinges and similar parts are now made of malleable iron and cast iron. With the large savings made in zinc consumption, it is still possible to get enough zinc to make such parts as carburetors, fuel pumps, ouside door handles, and some grilles, but the scarcity of aluminum is threatening the use of zinc even in these parts.

At present, the allotment of aluminum is 0.4 lb. per car. This has been spread out thin by reducing the aluminum content of zinc base die castings to a maximum of 2 per cent. Many castings can be made with as little as 1 per cent but the next move will be even a further reduction in amount of aluminum allowed so it will be the elimination of aluminum that will force still further removal of zinc rather than the scarcity of zinc.

As soon as research uncovers some other alloying agents or agent that will stop solution of iron in melting pots and goose necks and prevents adherence of zinc to dies, the use of zinc base die castings can again be stepped up.

Steel Radiators and Ferrous Pistons

The initial tightness of zinc caused a move to change entirely to copper for radiators but the early scarcity of copper complicated this picture. The desire now is to greatly reduce the use of this metal so attention is now being devoted to construction of as much of the radiator as possible from coated steel. The question of making the whole radiator of steel is also being actively investigated.

The almost complete elimination of aluminum from the automobile except for that used in zinc base die castings and for steel deoxidation caused a reversion to ferrous metal pistons. A number of large producers were in a very satisfactory position because of uninterrupted use of cast iron pistons, thus necessitating no change. A number of cars have used pearlitic malleable iron instead of cast iron. Some weight saving is obtained by so doing because

Tractor parts being hardened by induction heat. (Courtesy: Caterpillar Tractor Co.)

of the higher strength and stiffness of this material permitting lighter sections.

The natural course of development in bearing materials has led to considerable saving in the amount of tin used. This has occurred as a result of substitution of lead base babbits and to the use of extremely thin tin base babbit. The improved load carrying ability of the latter dictated its use prior to any shortage of tin so helped to prevent scarcity of this material.

Developments in Plating

The sequence of developments as affecting plated parts is interesting to follow with reference to the changes in metal restrictions. When nickel was first restricted, steps were taken to go from 0.0007 in. nickel and 0.0003 in. copper plus chromium to 0.0007 in. copper and 0.0003 in. nickel plus chromium or 0.001 in. copper plus chromium. Good results in exposure tests were obtained with such plates. A coating of 0.001 in. of copper only with a covering of chromium prevents rust but is unsatisfactory due to formation of a brown deposit due to copper "bleeding." Then the advent of copper scarcity made such a change inadvisable and together with the scarcity of chromium has finally brought about the elimination of all plating for decoration from the automobile. The same fate has befallen all decorations composed of stainless steels whether of the 18-8 variety or the straight chromium.

But the case of exhaust valves and manifold heat control dampers and pins is somewhat different. No adequate substitute for chromium has been found for making heat resistant steel so the use of chromium and nickel has been continued in these parts. Reduction in the use of chromium and nickel for such parts can be best accomplished only by decreasing the number of cars built.

Strategic Alloy Steels

Some car manufacturers were well ahead of the parade in the matter of eliminating strategic alloys from structural alloy steels. Manganese steels, in one case, molybdenum steels in another, and low chromium steels in still another, were in use in place of high nickel and chromium steels well ahead of the appearance of restrictions on these metals. Those using nickel steels quickly switched to other steels without sacrificing anything of durability. The development in the last few years of the technique for measuring hardenability has been largely responsible for the ease with which these changes have been made with a minimum of trouble.

Easy means of evaluating hardenability has also been responsible for a rapid exploration of the possible low alloy combinations for obtaining deep hardening steel without using restricted metals. This work has revealed that by suitable combinations of manganese, molybdenum, silicon, and chromium, within present restriction limits, all the hardenability required for any automobile part can be readily obtained. With the use of special deoxidizers the job will be possible with even smaller amounts of alloying elements. There is some question, however, whether these deoxidizers are going to be permitted but even so there seems to be nothing in the restricted use of alloys that will interfere with building of cars without any sacrifice of durability.

Machine Tools

by Tell Berna

General Manager, Machine Tool Builders Assn., Cleveland

In many respects the machine tools which will be built in this country in 1942 will be as different from those built during the last war as are the Flying Fortresses of today different from the "crates" flown by the intrepid aviators in the World War I. For during these intervening years research and design have been just as active in machine tools as have research and metallurgy in steel. The two have gone hand in hand—for the advances in the art of making special-purpose steels have made it much easier for machine tool builders to achieve the desired improvement in machine tool performance.

With the advent of cemented tungsten carbide cutting tools, there opened up new possibilities in speed of removing metal. But these new cutting tools had to be backed up with greater increased power. This required greater strength of structure, and particularly greater rigidity. Modern steels have made it possible in designing machine tools to attain the required strength and rigidity without the enormous increase in weight which would have been necessary with the steels of 25 years ago.

Special Machines

There have been designed and built many new special machines, many multiple-operation machines, to meet particular demands imposed by the defense program. The results in terms of increased speed of performance are remarkable.

A special horizontal drilling machine, for instance, in the plant of an aircraft engine manufacturer, performs 35 operations which formerly required 8 machines and does the work in 24 mins. instead of 4 hrs.

Another example is a vertical multiple spindle drill in an aircraft engine plant that does in 17 mins. what used to take two machines 1 hr. and 18 mins. In this plant there is also in operation a new vertical multiple spindle drilling machine for back-counterboring that drills 20 holes at once and does in 65 mins. what used to take 6 hrs. and 40 mins.

Before the emergency a company making aircraft parts was grinding valveseat inserts. With the emergency a centerless grinder was designed for plunge grinding that particular job. Production was 200 parts per hr.—production on the new machine is 1500 parts per hr.

A company making airplane propeller shafts now has in operation a new five-spindle drilling and reaming automatic that does in 40 mins. what used to take 3 hrs. and 22 mins.

Along with increased speed of performance has come a general trend toward greater accuracy of performance. Many operations throughout the defense program must be performed to very narrow tolerances and the requisite accuracy must be built into machine tools.

Today's speed and accuracy would in many cases have been very difficult of attainment if the machine tool industry had been working in the steels available at the time of the last war.

Substitute Materials

Thus far machine tool builders have suffered very little from inability to obtain metals desired. This is due of course chiefly to the fact that machine tools from the very beginning have had a very high pri-

ority rating. Substitutions of metals or materials have therefore not been necessary. It is true that some changes have been made in the use of metals—for instance, some companies are no longer chromium plating handles or levers of machines—but this is due chiefly to the desire to avoid unnecessary work in the face of the pressure of production for national defense.

It is certainly to be hoped that machine tool builders will not experience any shortage of the best possible metals and materials, for upon the accuracy of performance of the machine tools in our national defense plants depends the accuracy of performance of our planes, guns and tanks. In machine tool building no chances can be taken, and an unbroken supply of proper materials is therefore a definite necessity.

Heavy Machinery

by H. L. Day

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With these last two decades of prodigal metallurgy now relegated to history by our present emergency, we must continue to search for substitutes that will suitably replace scarce or unobtainable materials. Lest discouragement get the upper hand, it might be advisable to consider some of the "blessings" that paradoxically are arising from the ashes of our metallurgy of yesterday.

Less Use of Alloys

In the manufacture of heavy machinery, the metallurgical benefits of this present period are quite apparent. Just as after the close of the last world conflict, the automotive industry came to use less and less of the fancy alloy steels, so today the manufacturers of heavier machinery are finding that there has often been little excuse for their use of many of the more complicated alloys. Special cast irons, steel forgings, bearings, fittings, and the like—all in their turn have come under the critical gaze of the 1941 metallurgical engineer, and revised but sound engineering is the order of the day.

The universally felt alloy steel shortage created the initial problems of this period. In one case it was surprising to find that an alloy steel was being used purely for sales-appeal purposes, the stresses involved being a safe low for even annealed machinery steel. In another case nickel was omitted from an alloy steel, leaving the balance of alloys essentially unaltered, with no apparent reduction in the serviceability of the parts.

It is indeed fortunate that in heavy machinery, the bearing loads predicate the size of shafting, that compression loads are seldom serious, and that tension members can frequently be designed to produce low stresses. In many of such applications well made carbon steel normalized or annealed, or both, will provide the required stress resistance.

Occasionally a heavy section requires a moderate penetration of hardness to provide strength in a deep-seated stressed zone, in which case 0.10 to 0.15 per cent V in the presence of 1 per cent Cr and 0.25 per cent Mo will produce satisfactory results. The vanadium will permit a higher quenching temperature with beneficial results to the inner portion of the heavy section.

The current shortage of low-silicon pig iron has intensified the problem of obtaining strong and sound gray iron castings in heavy sections. Diluting the cupola charge of high-silicon pig with excess steel scrap has many disadvantages, among which is the steel scrap shortage that always precedes a pig iron scarcity. But where heavy cast iron sections are to be deeply machined, and where strength and soundness are important, high-silicon pig can be used, sweetened with pig that carries alloy derived from the ores used in its manufacture, or with additions of chromium, copper, or molybdenum.

Metals in Bearings

Bearing materials in heavy machinery likewise have been better than required in many cases. Recourse to recalculated loadings and to long-experience tables has indicated that the high-tin type of babbitt, for instance, can be replaced by high-lead-bearing metals. Steel-backed bronze and babbitt shells will also produce equivalent, and often better results than the same bearing in solid metal. Likewise the use of protective coatings for base metal is proving to be a satisfactory substitute for solid non-corrosive materials of ferrous or non-ferrous metals.

Greater Use of Castings

Because the conservation of time is now most important, and in view of the possible marked savings in machine man-hours, the use of castings will become more and more prominent, and will eventually assume, in industrial use, the importance now being demonstrated in the ordnance field, where forgings were previously almost unanimously specified. For many of the applications in the components of heavy machinery, the stress is maximum at the machined outside surface. With steel castings made closer to shape than most large forgings and with characteristically sound outside metal, in place after machining, the well-made, X-ray inspected and heat-treated casting of steel will become more and more useful than ever when we return again to more rational ways of living and working.

Thus, the blessings of this emergency may be said in some measure to outweigh the troubles that have been experienced to date in the application of materials. An experience record of new practices is being established. There is slowly being overcome the wasteful use of heavily alloyed steel.

Finally, those ultimate consumers with weird and unsound ideas concerning the metal composition of standard manufactured products, now find themselves in a sellers' market. The point has been reached where a delivery is more important than a theory, and thus in due time we may see nearly eliminated the specialty manufacturing of non-standard analyses, to which there may never be a return in the normal times that are bound to be restored in the heavy-machinery manufacturing business—and elsewhere.

Valves, Pipe and Fittings

by J. J. Kanter

Materials Research Engineer, Crane Co., Chicago

Since the start of the Defense (now War) program, heavy demands have been made upon the valve, fitting, and piping manufacturers. Piping equipment is indispensable to all of the plants of the now vital industries as well as to the actual tools for defense and victory. Without the products of the piping industry, expansion and maintainence of the production of power, oil, chemicals, shipping and other transportation would be unthinkable. It is, therefore, apparent at once that the allocation of the materials required to engage the full activity of the valve, fitting and piping industry is unquestionably necessary.

The principal materials used for piping products for steam power and oil refinery work must be, by the nature of the demands made upon them, metallurgical. Substitutions, therefore, which would effect any significant conservation of metal in this industry, are extremely limited possibilities. The greatest effect which war time stringencies have had thus far in affecting valves, fittings and piping has been to direct the priorities for their manufacture and distribution to essential needs. Thus, certain of the facilities of the industry normally devoted to the manufacture of consumer goods, now must be given over to more urgent purposes.

Standardization and simplification of the lines of manufacture, as well as materials requirements serve a most eminent purpose in making available the needed piping. This factor has been recognized by the various specification and code-making bodies, sponsored both by government and industry, with the result that numerous bottlenecks and extravagant practices have been dispensed with. This is probably the most effective manner in which the situation can be helped, because of the unique set of engineering requirements limiting possibilities of ready changes in either materials or design. Piping equipment, it might be asserted, has already developed and evolved along very practical and economical lines, leaving but little opening for any sudden drastic changes of accepted practices, which would not lead to serious technical difficulties.

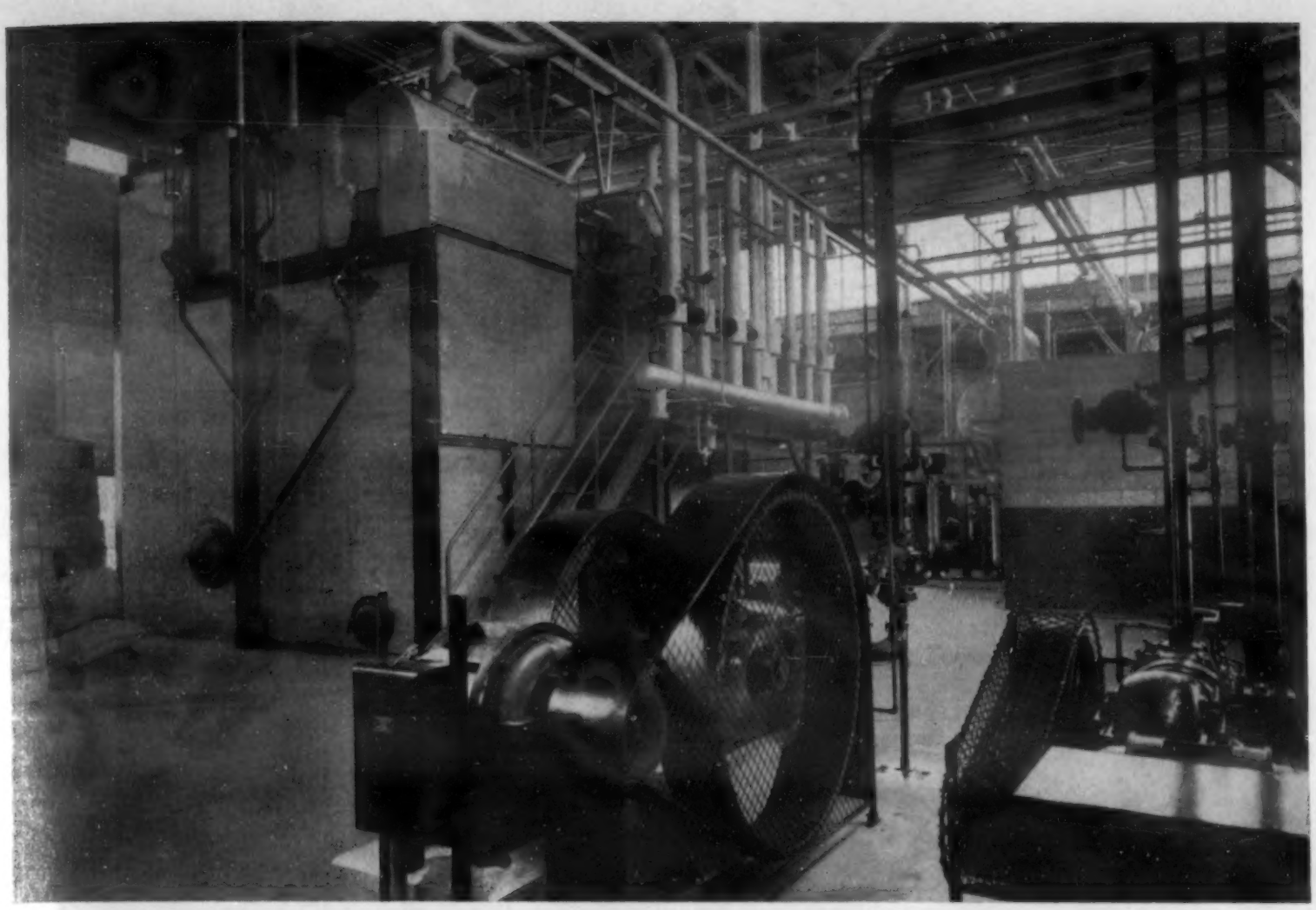
Metals for High Temperatures

Fortunately, under emergency conditions, the steel requirements for piping equipment do not make great demands for alloys of strategic moment. Carbon steels and cast irons serve the multitude of purposes for low pressures and temperatures not exceeding 550 deg. F. Where temperatures exceed 550 deg F., the use of cast irons are excluded entirely in standard practices, but under the critical conditions with which we are faced, some consideration to extensions of the present limitations may be warranted, particularly in the case of malleable cast irons. The use of alloy steel in piping equipment at temperatures not exceeding 750 deg F. is indeed small, the most notable use being for high strength bolting, for which chromium-molybdenum steel of the A.I.S.I. 4100 type is used, and it might be noted that extensive use of alloy bolting is curtailed to a considerable extent by the modern practices of using welded joints wherever practicable in preference to flanged joints.

In steam power practice where high pressures are employed and temperatures exceed 750 deg. F., extensive use is made of carbon-molybdenum steel pipe, forgings, and castings. It is a most fortunate incidence that so much is accomplished in attaining excellent high temperature strength properties through the alloying with steel of one-half of one percent of molybdenum—a domestic product for which there is no apparent threatened shortage. Some controversy still exists among engineers as to the correct metallurgical requirements to insure carbon-molybdenum steels at their optimum properties for high temperature services. Recently, however, a grain size requirement in A.S.T.M. specification A206 for carbon-molybdenum pipe involved in this controversy, was made optional for the duration of the emergency, in the interest of expediting production of this important product.

Materials for Oil Refineries

The oil refining industries needs of chromium-molybdenum, and nickel-chromium highly alloyed steel compositions for corrosion resistant piping is probably increasing despite the urgency to conserve alloying ingredients. Construction of new refinery



Boiler room for a cemented-carbide plant showing multiplicity of valves, pipes and fittings. (Courtesy: Carboloy Co.)

units, for the production of the high octane gasoline essential to aviation, trend toward an increased demand for materials combining a high degree of high temperature strength and chemical stability. This implies greater use of nickel and chromium, whose use is warranted only for urgent needs, but again there can be little question regarding the legitimacy of their use toward the production of defense fuel.

The special alloy bolting requirements for high temperature plants are imperative. Although welded joints have displaced many bolted flanges, there are still many situations in refinery, power station, and marine piping where the bolted joint cannot be dispensed with. Materials with enough alloy content to establish both high elastic strength and high temperature creep and relaxation resistance must be used if the dependably tight joints upon which rests the safe and successful operation of high temperature-high pressure plants are to be maintained. The list of alloy steels which has been set up for emergency manufacture, based upon past large tonnage requirements, perhaps does not sufficiently provide for special requirement steels such as for high temperature bolts, where the tonnage requirements are relatively small, but none-the-less indispensable to the operation of plants upon which much depends.

Numerous problems have arisen in the manufacture of piping equipment with regard to uses of copper, zinc, and tin, where the acute shortages demand curtailment of every dispensable use. Problems arising due to these shortages are being met as expeditiously as possible, and will affect principally consumer uses of the industries' products. Expanded application of cast iron where brass has been the practice is already in the making, conserving copper and zinc. Zinc will also be conserved by limitations upon the use of galvanized fittings. Again it is fortunate that defense requirements are based primarily upon iron and steel, rather than non-ferrous metals.

Electrical Products

by P. H. Brace and W. M. Layton

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The basic materials for the construction of electrical apparatus may be regarded as ferromagnetics, conductors and non-conductors, that is, iron, copper and insulation. However, since electricity and means for

Coils of silicon steel for transformer cores. (Courtesy: Westinghouse Electric & Mfg. Co.)

making, transporting, controlling and applying it have become so intimately woven into the fabric of our existence, the electrical industry has brought into its service literally hundreds of special materials and has taken an active part in the creation of many of the newer ones.

The scarcer metals are extensively used in order to achieve certain physical results, to enhance appearance and to combat deterioration due to corrosion and the effects of high temperatures. The problem now is to continue essential service by means of devices built from the more plentiful materials together with such amounts of the more critical materials as may be available after providing for our war effort. This is involving significant changes in design so that the problem is not merely one of substitution but that of adaptation as well.

Substitutes for Copper, Nickel, Chromium

As a substitute for copper in conductors, aluminum is often thought of. However, since aluminum has for the time being become a precious metal, such a shift is not attractive particularly in apparatus such as transformers and most rotating equipment where it is important to have the best possible volume conductivity. Several writers have suggested that our hoard of monetary silver be used in place of copper for electrical conductors.

Much of the nickel and chromium which have

been so much used for decoration and protection against corrosion in both industrial and household equipment is being replaced by vitreous enamel or specially prepared oxide coatings applied to steel or cast iron. Ceramic coatings have been considerably improved lately and further progress is to be expected under the stimulus of present conditions. In some cases indium plating may offer an "out" where wet corrosion is a problem although the cost of that metal is too high for the generality of applications.

Molded plastics have been very energetically developed during the past few years and can in many cases be substituted for aluminum and zinc alloys where, by redesign, working stresses can be adjusted to the strength of the plastic. An important example is washing machine agitators.

Cast iron is being substituted for aluminum and zinc-base die castings in many places where lightness or ease of fabrication of more or less intricate shapes have been desirable but not essential. Waffle irons and fan bases are cases in point. There are those who believe that cast iron is the proper thing for waffle irons anyhow.

Liquid Expansion or Vapor Tension Devices

The most important materials to the appliance engineer are the nickel-chromium and nickel-chromium-iron alloys used in heater elements and the various special-purpose alloys comprising nickel and chromium that are essential components of the "bimetals" used in thermostats and other temperature-responsive devices, and substitutes are not available. Here the problem may become not one of substitution but that of finding other ways of doing the jobs now done by bimetals. This may well mean that liquid-expansion or even vapor-tension thermometric devices may have to be used in some equipment now controlled by "bimetal" temperature-responsive devices. In industrial furnaces non-metallic heating elements, based on silicon carbide, can be used to perform many of the services of nickel-chromium alloys in new furnaces. In existing furnaces such replacement is generally impracticable for both structural and electrical reasons.

Straight Chromium Alloys

Many substitution difficulties arise from the fact that designers have sought to accomplish their ends with the minimum of cost and that these ends have been achieved by close correlation of special materials and special designs. However, when the special materials cannot be had, we must content ourselves with securing essential functioning in the best manner we can, recognizing that the substitutions frequently carry penalties of increased weight, bulk and cost. Straight chromium-iron alloys of 16 to 18 per cent Cr have proven a serviceable substitute for the 18 and 8 chromium-nickel alloys although redesign has in many cases been necessary to compensate for the lesser ductility of the chromium-iron alloys. Parts deep drawn from 18 and 8 were successfully replaced by welded assemblies of simple stampings of 16-18 per cent chromium iron. Even at normal metal prices the substitute design is the more costly although serviceability has not been impaired.

In the field of magnetic materials it is fortunate that the fundamental constituents for transformer cores, iron and silicon, are plentiful. Nickel, cobalt, aluminum, molybdenum, tungsten and chromium play essential roles in permanent magnet steels and here there appear to be no substitutes, except possibly certain specially treated combinations of iron and cobalt oxides. However, since the amounts of scarce materials going into such special magnet materials is relatively very small and the gains in performance due to their use are very great, efforts here are being directed along design channels with the thought of conservation rather than substitution.

Molybdenum is proving a very capable alternative for tungsten in both tool and structural steels. Modern refinements in heat-treating procedures, many of which are associated with electric heat, electrical control and controlled furnace atmospheres are considerably extending the possibilities of carbon steels of low alloy content. Steel tonnages are so large that elimination of even small percentages of critical alloying elements—nickel, chromium, tungsten, for example—can account for relatively large savings of these special metals.

Soldering and Brazing

In the joining of metals, lead base solders comprising a few per cent of silver can frequently be substituted for the usual tin base solders. Copper phosphorus alloys can be used in place of the conventional silver-copper-zinc "silver solders" except for the brazing of iron and steel parts. Wider application of arc welding, resistance welding and timed "shot-welding" techniques can in many cases eliminate the use of special solders or brazing alloys involving critical metals.

In the insulation field domestic mica can be substituted for much of the foreign mica customarily used so far as the material itself goes. However, the production of satisfactory mica splittings will require the development of special skills not now available in this country on any large scale.

Tung oil, which has been an important basic material for insulating varnishes, is being replaced by processed oils of domestic origin, by synthetic matrials and by natural oils of South American origin.

The application of synthetic materials based on coal, salt, chemical plant and power present a picture which may change abruptly on short notice due to unpredictable shifts of emphasis on defense needs. Explosives and many other war materials are built on much the same basis as are many of the more capable new insulating materials.

The Problem of Luxuries

Under present conditions we must look carefully at our definition of "luxury," bearing in mind that many of the widely marketed special electrical devices find sale because they conserve human effort. Flashy automobile trim seems to many to come definitely in the category of luxury; however, no man who has had to do a washing by hand is likely to place a washing machine in this classification. Refrigerators have an important bearing on the care and efficient use of foodstuffs and, rather directly on health. When refrigerators are described as luxuries, one wonders where all the ice is now to come from to do their essential job.

If, as seems likely, we are in for a long struggle it would seem worthwhile to appraise our thoughts as to luxuries on the basis of conservation of man-hours and woman-hours in order that our national effort may be most effectively carried out. Judicious mechanization at home can contribute greatly to the vast job supplying to our fighting men the necessary tools of war.

Containers

by H. S. Van Vleet

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During the past 10 years the manufacture of tinplate for food containers has passed through a revolutionary change in practice, from the old hot pack rolling to the new cold reduced, continuous strip method; the latter representing 25 per cent of the total tinplate production in 1936 and 85 per cent in 1940. The change in method of manufacture has been accompanied by improvements in tin plate quality with respect to corrosion resistance, ductility and control of physical properties, uniformity of gage from edge to center of the strip and a marked improvement in sheet dimensions through better shearing.

The tinplate industry in 1941 was prepared to handle the large increase in volume which has accompanied the increased demands on the container industry. The happy marriage of the desirable physical characteristics of sheet steel and the corrosion resisting qualities of tin has provided the can maker with a raw material for can bodies and ends possessing adequate structural strength, attractive appearance and solderability, which are so essential for the highly mechanized can making industry and subsequent service of containers for food products.

Savings Made in Tin

A shortage of tin would have far reaching consequences upon the distribution of food. There are no known significant commercial deposits of tin ore in the North American continent. This condition was early realized in the present emergency when our government entered into an agreement with the International Tin Council to provide a more rapid importation of tin and tin ores. The OPM has requested the tinplate producers, the can manufacturers and canning industry to cooperate in the conservation of tin wherever possible. This has involved a 10 per cent reduction in the weight of tin coating applied to all tin plate except that used for the more corrosive food products. By extending the use of electrolytically coated plate with light tin coating weights, further savings in tin consumption will be effected. On many non-food containers a substitution program has been effected wherein terne plate, a lead-tin alloy coated sheet carrying 20 per cent tin and 80 per cent lead, has been substituted for tin plate.

Further savings in tin consumption in the container field are being effected by applying organic finishes directly to the steel sheet for non-soldered portions of many cans. The extent of this type of conversion will depend upon the conditions of service and the products packed. For products, such as coffee and oil, it appears that the lacquered container will provide sufficient service life to carry the product from the producer to the ulitmate consumer. The war with Japan has accelerated this phase of the program.

Lacquer Coated Steel

In the case of wet packs, such as corn and peas, the lacquer coated steel container will not provide adequate service life without some form of steel pretreatment. The shipping, fabrication, and application of uncoated steel presents several problems not ordinarily encountered with tin plate; first, protection from rusting during shipment and warehousing of the steel sheets from the mill to can making plant must be provided; second, prevention of underfilm corrosion is necessary for coated steel sheets during warehousing and subsequent service of the can when subjected to conditions of high relative humidity and temperature; and third, the success of a lacquer coated steel can packed with wet products is predi-

cated wholly upon the excellency of coverage and adherence of the lacquer film to the metal base. The coating system must withstand the preserving process for food which may require a cooking time as long as 190 mins. at a temperature up to 250 deg. F. Provision for these requirements is currently under commercial development through proprietary treatments of sheet steel.

Had the substitution of tin as a protective coating for containers been a simple one, a satisfactory material would have been found long ago. No other single metal coating is available which will fulfill all the requirements of tin plate. Among the metals showing some promise through past experiments are nickel, chromium and aluminum, all of which at the present time are under strict priority and are currently less available than tin. In fact, for those applications where nickel and aluminum in recent years have gained a foothold in the container field, it has been found necessary to return to tinplate. The suitability of nickel in combination with chromium, tin, or zinc has been studied for several years and it is believed that these metals will eventually find application on the basis of demonstrated superiority in appearance, performance, or relative cost in comparison with tin plate.

Silver as a Substitute

Considerable publicity has been given to silver as a substitute for tin in the container field. On an equivalent coating weight basis silver is 14 times as expensive as tin, whereas on an equivalent cost basis the silver coating on steel does not provide adequate rust prevention or corrosion resistance to warrant consideration of silver for single trip containers. A 2.5 per cent silver-lead solder is under investigation. The high melting point of the eutectic and absence of a spread between liquidus and solidus temperatures introduces a problem of wiping excess solder from the can that will require extensive equipment changes for satisfactory performance.

Household and Other Civilian Products

by Henry R. Clauser

Assistant Editor

WHEN THE DEFENSE PROGRAM was first inaugurated in the middle of 1940, production of non-defense civilian goods continued on its way almost undisturbed with defense production tagged on behind. In the last part of 1940 and continuing through 1941 the relative position of these two types of production was reversed. While the defense program took over the prerogative, the manufacture of civilian goods, which was deemed less essential to the defense of our nation, assumed a subordinate role.

The curtailment of non-defense production was largely brought about by the application of the priority system. As the defense program gained impetus and demanded increasing proportions of the total available raw materials, shortages, of course, were foreseen. To forestall the impending shortages of some of the vital supplies, the government introduced preference ratings or priorities with the purpose of assuring defense production the necessary materials to carry on. Naturally, the non-defense industries suffered, because they came second to defense; and in many cases, second meant doing without.

Up until the beginning of March, when aluminum and machine tools were put under mandatory priorities, the restrictions had been only voluntary. From that time on priority controls over all industry tightened. Nickel, magnesium, neoprene shortly were put under full priorities. By mid-year the use of all of the most vital metals to both defense and non-defense production was closely controlled.

Substitution Problems

For the engineers in the metal industries producing consumers goods, two problems were created by the shortages. First, where the metal formerly used was no longer available the engineer had to shop around for a substitute material, an alternate, or a new material. [For the purposes of this discussion a substitute material is referred to as a substance which can take the place of the old material with only a minimum of change in design of the product and processing; an alternate is usually an entirely different material requiring considerable redesign of the product and processing methods; and a new material is one not formerly in existence.]

The design engineer in his choice of a substitute had to keep the factors of economy, quality, and

availability in mind. As shortages spread and enveloped more and more different materials, the factor of availability became the paramount consideration in the design of non-defense items. In many cases a consumer product experienced several different changes in its material make-up due to the transfer of a metal from the available to the unavailable class.

For example, in the manufacture of refrigerator display cases, the cooling coils were originally made of aluminum and copper. The aluminum made up the outer fin assembly which covered an inner tubing of copper. Because of successive shortages in various metals the coils were redesigned for tinned copper fins with an inner tube of copper. This later had to be changed to a fin assembly of steel and a copper inner tube. Finally, because of the shortage of copper, the fins and inner tube were both made of steel with special surface treatments.

The second problem confronted by the engineer was, and still is, an outgrowth of his first one. That is, the use of a substitute in the manufacture of civilian products often necessitates many changes in processing equipment and methods of production. Every attempt was made to find substitute materials which require only minor changes, instead of alternates and new materials which often entail drastic revamping or replacement of equipment at considerable cost and loss of time. Availability was usually the deciding factor, and so it was necessary to make the best of what could be had, even if at the expense of cost and efficiency.

Substitutes and Quality

The question is often asked: How has the quality of the finished product been affected by the use of substitutes? This can be answered in three ways. In many cases there has been no appreciable change, while in others the quality has suffered to a greater or less degree. And in some instances the changes in material have represented improvements which will ensure the continued use of those substitutes after the emergency.

A typical case of uncovering a substitute which will probably become permanent because of its superior qualities was that of replacing aluminum with glass in recording disks. The search for a new base material for professional instantaneous recordings was begun early in 1939. Tests were made with cardboard, hard fibre and plastics, and then zinc, copper and steel. Zinc and steel were found to be the best, but zinc became scarce and steel was not entirely satisfactory on further tests.

Experiments with glass had been carried on previously, and with this beginning plus some more work, processing difficulties were largely eliminated. The recording engineers, as a result, have found that the glass base disks sound better and clearer and generally equal the performance of aluminum.

Some Substitutions in Civilian Goods

A detailed review of the specific substitutes made in all the manifold parts of civilian products during the past 12 months or so would be too lengthy to fit into this short article, but a general survey might help.

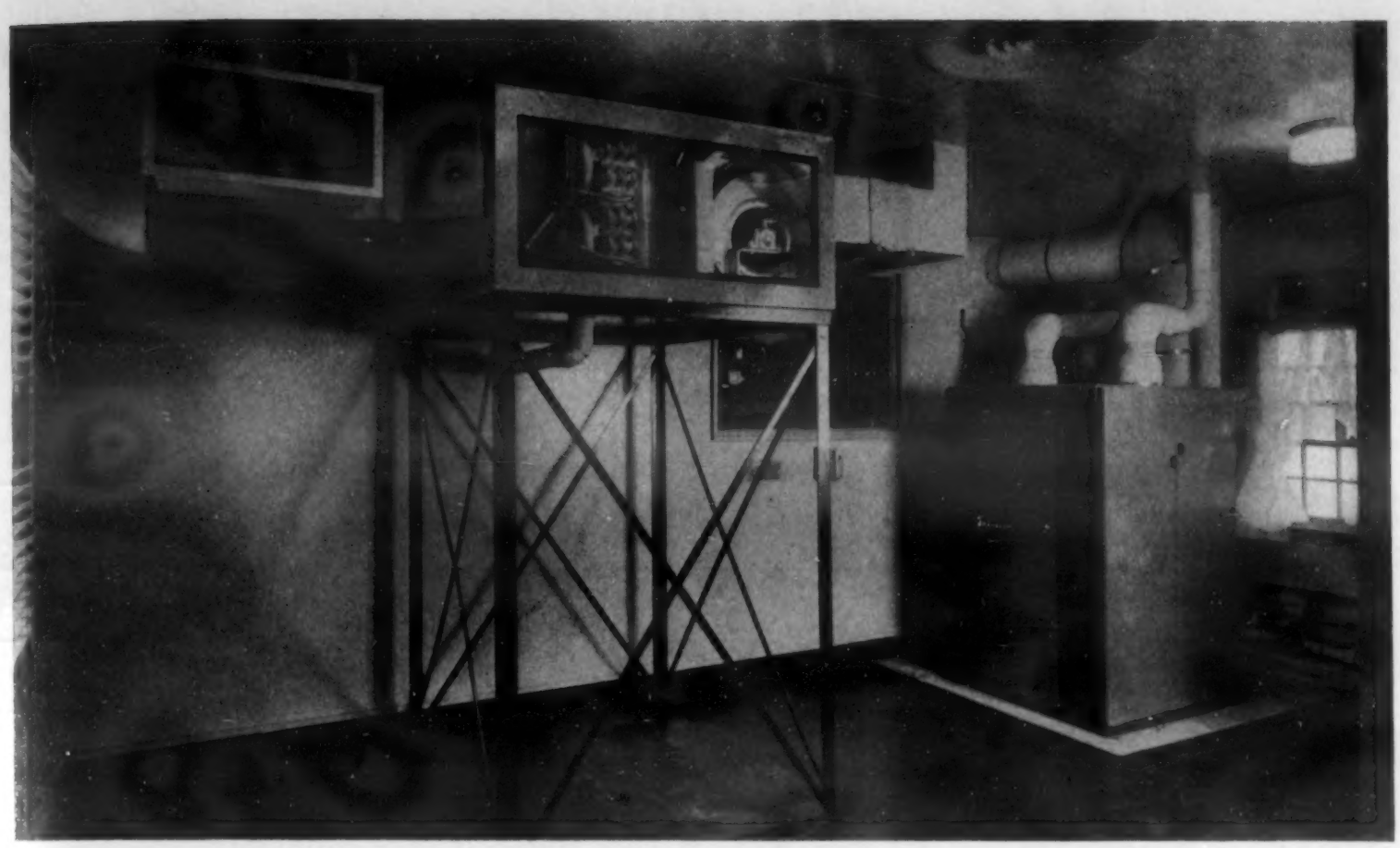
Refrigerators, both mechanical and electrical, were one of the first non-defense items to feel the material shortage and consequently a great many substitutions have been made. Some of these are: Vitreous enameled steel for the evaporator in place of brass or stainless steel; rubber with wire inserted handles and stiffeners for ice cube trays; enameled steel instead of aluminum in cooling unit fronts and doors and vegetable pan fronts; asbestos board is being used to replace metals for the back panels on some refrigerators; acrylic resins are being adopted for a variety of parts such as evaporator doors, panels and nameplates, and various handles; cellulose plastics are being increasingly used for control knobs, handles, drip pans, crisper tray fronts, doors, and door panels.

The radio industry, with its heavy dependency on aluminum, set up a bureau for the specific purpose, among other things, of finding ways of conserving aluminum. As a result lead, copper, plastics, paper, iron and steel were substituted in variable tuners, coil shields, capacitators, chassis, and loudspeaker magnets. For example, sets designed for permeability tuning, using high permeability sintered iron cores and sleeves, in tuning coils, are able to dispense with aluminum shields. Only in electrolytic condensers was the bureau unable to find a workable ingredient to replace aluminum. Other substitutions include scrap metal or Rochelle salt for speakers, metal sprayed on cardboard for interstage shielding and tube shields, fibrous or ceramic materials for chassis pans to conserve steel, and paper or cellophane sprayed with metal for condensers.

The hardware and the building industries were seriously confronted with the problem of substitutions because a great majority of their items were made of metals high up on the "forbidden" list. Only where operating and wearing operations absolutely demanded was the use of copper, copper alloys, or nickel-copper alloy permitted. In other places cast iron, wrought steel, malleable iron, plastics, pottery, wood, and glass were specified. It was estimated that the resulting saving would be 90 per cent of the normal use of copper and its alloys in those industries.

Twenty-six of the 30 standard finishes listed in the Federal Specifications have been eliminated. Some of the greatest savings from this simplification will be in nickel and chromium. Where zinc-coated or cadmium plated hardware was formerly employed, the specifications call for japanned and plain steel.

For copper roof materials, sheet asbestos board or shingles have been substituted where only ordinary



Household air conditioning equipment will be subject to considerable "substitution" in its design and manufacture. (Courtesy: Nash Kelvinator Co.)

service is required. For corrosion and high temperature work Transite—a dense material made of cement and asbestos under terrific pressures—has been adopted for many applications.

Plywood has received wide consideration as a substitute for sheet metal. It is made of three or more layers of wood, welded together with a resin under 300 lbs. per sq. in. pressure; it is impervious to water, and tests have shown it to be as strong as mild steel. Plywood can be stamped out with metal dies or cut with power shears. Its range of usefulness is wide in replacing steel and other scarce metals. When coated with special compounds it becomes acid and alkaline resistant and is useful in hoods and ventilating systems.

The substitutions in kitchenware and general household appliances are much too numerous to list, but a mention of a few will suffice to show the problems confronted.

Use of aluminum in washing machines has been reduced from an average of 6½ to 3 lbs. per washer. To make possible this reduction, aluminum tubs have disappeared and enameled sheet steel tubs are being used in their place. Porcelain enamel or cast iron is also a suggested replacement. Stoves, ovens and ranges are using porcelain enamel stampings in place of stainless steel and aluminum for oven liners and broilers. Zinc oven vents have been replaced by a steel vent with a baked japan finish. Oven racks, formerly nickel-finished, are now plain steel finished in gun metal blue.

The nickel plating on electric toaster steel parts is put on thinner by first placing a black oxide finish on the bare steel. Aluminum reflector plates are being replaced by plated sheet steel, and nickel has been eliminated from the shell by vitreous enameling the surface. Kitchen utility cabinets have reverted back to the material used many years ago—wood instead of steel. The aluminum cooking utensils, following the precedent they set in World War I, have ceased to be. Enamelware has taken over.

Conclusion

The metallurgical engineer in the civilian products industries has learned much in his quest for substitutes during the past year that will compensate, at least in part, for the headaches that material shortages have caused him. He has become more intimately acquainted with the properties, uses and applications of the metals with which he works. Never before have the properties and characteristics of established metals and alloys been studied more thoroughly and put to more varied uses. Alternates and new materials have been discovered; in many cases they are doing a better job than the material they replaced and will become permanent. Methods and processes of fabrication have undergone changes imposed upon them by the new requirements of substitutes. Many of these changes are advances and improvements, and will continue to be used. All in all it is likely that civilian industries will come out of this war very much wiser.

Reference Table of

ALTERNATES AND SUBSTITUTES

Compiled by H. R. Clauser

This is the first section of a comprehensive and detailed reference table of substitute applications developed within specific industries and in the design of specific products. Other sections, each devoted to an individual group of products —automotive, electrical, industrial machinery, etc.—will ultimately provide a close-to-complete record of substitute-design practice. It is recognized that at the moment many of the substitutes listed are "scarce", but eventually they will again become available and can be used.

Readers are urged to file these tables for permanent reference, for they are a part of a broadened campaign by METALS AND ALLOYS to give metallurgical engineers a continuous flow of tabular reference data about materials and processes.

SECTION 1—HOUSEHOLD PRODUCTS

In these tables the "scarce" metals are given at the head of the columns and the substitute metals are found in the body of the table.

Products and Parts		Scarce Material												
		Aluminum	*Aluminum Castings*	*Brass*	*Bronze*	*Chromium Plate*	*Copper*	*Galvanized Steel*	*Nickel Alloy*	*Nickel Plate*	*Steel*	*Stainless Steel*	*Tin Coatings, Alloys*	*Zinc Die Castings*
Refrigerators	Cooling coils				Steel, surface treated		Steel, surface treated						Steel; Pb-Ag. solder	
	Food compartment shelves											Porcelain enamel stampings	Porcelain enamel stampings	
	Interior fronts	Steel, cadmium plated											Steel, cadmium plated	
	Thermometer housing	Plastic		Plastic; painted steel									Pb-Ag solder	
	Panels, handles		Acrylic resins											Acrylic resins
	Ice-cube trays	Enameled steel; rubber												
	Evaporators			Porcelain enamel								Porcelain enamel		
	Compartment doors	Enameled steel												
	Handles, hinges		Steel; plastics	Steel; plastics	Steel; plastics	Painted steel; plastics					Plastics	Plastics; plain steel		Steel or plastics
Stoves and Ranges	Hoods							Painted steel; plywood			Coated plywood			
	Oven liners		Porcelain enamel stampings									Porcelain enamel stampings		
	Cooking well	Enameled steel												
	Oven vent			Plastic; steel; ceramics										Porcelain; iappanned steel
	Door handles		Plastics	Plastics; steel	Plastics; steel	Sprayed enamel				Organic finishes	Plastics	Coated plain steel		Plastics
	Broilers		Porcelain enamel stampings			Porcelain enameled steel				Porcelain enameled steel		Porcelain enamel stampings		
	Oven racks			Painted steel	Steel, blackened				Steel, gun metal finish	Steel, gun metal finish				
	Economizer sheet	Porcelain enamel steel						Enameled or painted steel				Porcelain enameled steel	Porcelain enameled steel	
	Burners, burner heads		Cast iron, plain or enameled							Unplated iron				
	Gas range connectors			Steel; cast iron	Steel; cast iron		Steel; cast iron			Steel or cast iron				
	Trim			Painted steel; plastics		Heat resistant paint				Heat resistant paint		Painted steel		
Furniture		Wood; painted		Painted steel; wood	Painted steel; wood	Painted steel; wood					Wood	Wood, painted		
Household lamps		Cast iron, wood	Cast iron, wood	Cast iron, wood	Cast iron, wood	Wood						Wood	Pb-Ag solder	Cast iron, plastics

Products and Parts		Scarce Material												
		Aluminum	*Aluminum Castings*	*Brass*	*Bronze*	*Chromium Plate*	*Copper*	*Galvanized Steel*	*Nickel Alloys*	*Nickel Plate*	*Steel*	*Stainless Steel*	*Tin Coatings, Alloys*	*Zinc Die Castings*
Washing Machines	Wringer parts	Steel	Cast iron	Cast iron; plastic; steel	Cast iron; steel									Cast iron; steel; plastics
	Tubs	Enameled sheet steel							Enameled sheet steel			Coated plain steel		
	Drain board	Steel stamping	Steel stamping										Steel stamping	Steel stamping
	Agitator	Enameled sheet steel	Plastic											
	Clutch handle		Cast iron		Cast iron									Cast iron
Vacuum Cleaners	Fan blades	Plastic, steel stamping		Steel stampings										
	Dome, case hoods, nozzles, handles	Plastic		Plastic; painted steel		Non-metallic finish					Wood; plastics	Coated plain steel		Cast iron; steel; plastics
	Fan housing		Cast iron											Cast iron
Toasters	External shell									Porcelain enamel				
	Chassis										Glass		Pb-Ag solder	
	Reflector plates	Plated sheet steel								Thinner plate				
	Heating elements								Low-Ni or Fe-base alloys					
Electric fan bases			Cast iron; plastic; wood	Cast iron; plastic; wood	Cast iron									Cast iron; plastic; wood
Trays, pans, pails, cans, buckets		Plastic; plywood; glass						Plastic; plywood; glass			Plastic; plywood; glass	Plastic; plywood; glass	Glass; Ag plate; plywood	
Roofing							Sheet asbestos; plywood	Sheet asbestos; plywood			Sheet asbestos; plywood		Sheet asbestos; plywood	
Roof gutters							Wood; ceramics	Wood; ceramics					Wood; ceramics; pb solder	
Radios	Chassis	Fibrous or ceramic material									Fibrous or ceramic material		Pb-Ag solder	
	Condensers	Steel; iron; silver		Steel; iron; silver			Steel; iron; silver						Pb-Ag solder	
	Shields	Metal-fiber; iron core coils												
	Tubes	Alkaline earth getters		Steel posts, bases			Iron anodes		Iron, molybd'm, anodes		Glass envelopes			
Kitchen Utilities	Baking sets and dishes	Glass; plastics								Glass; plastics		Glass; plastics	Glass; plastics	
	Cooking utensils	Porcelain enameled steel; glass	Cast iron; steel; glass			Cast iron; porcelain; glass	Cast iron			Cast iron; porcelain; glass			Cast iron; porcelain; glass	
	Sinks								Porcelain; porcelain enameled			Porcelain; porcelain enameled		
	Kitchen cabinets										Wood		Wood	
Furnaces and Parts	Casings							Duct board; plywood			Duct board; plywood			
	Stoker transmission case		Cast iron											Cast iron
	Flues ducts							Duct board; plywood					Duct board; plywood	
Hot water tanks, pipes				Cast iron pipes			Enameled; cast iron pipe	Glass lined; enameled	Glass lined; enameled					
Bottle caps		Paper; painted steel		Paper; plastics; steel							Card-board; plastics			
Flyscreen		Plastic; painted steel		Plastic; painted steel	Plastic; painted steel		Plastic; painted; steel	Plastic; painted steel						

New Materials and Finishes of 1941

by FRED P. PETERS

Managing Editor

NINETEEN hundred and forty-one will be remembered in metallurgical engineering history more for the new applications of old materials and for the design-replacement of one established material by another than for any large number of genuinely new materials and finishes that first faced a specification during that year.

Nevertheless, the list of new proprietary trade-named products recently introduced is long, as a glance at the 8-page table that comprises the bulk of this article will show. Not yet christened (and not included in the Table) but of potentially great importance are a number of new materials and alloy compositions, information on which became available through research reports rather than through commercial announcements in 1941. Most of the new alloys of this nature were developed in this country; a few interesting reports emanated from Germany, but because these may not give a representative picture, owing to the irregularity of receipt of foreign journals, only American developments are discussed in the paragraphs that follow.

New, Untabulated Steels

Free-machining stainless steels containing bismuth, described by Pray, Peoples and Fink, of Battelle Memorial Inst. (Am. Soc. Testing Materials, Preprint No. 29, June 1941 meeting), were reported to possess much improved machinability, and without noticeable deterioration of corrosion resistance. Bismuth contents from 0.1 to 0.5 per cent Bi were found to be best.

Comstock, of Titanium Alloy Mfg. Co. (Am. Soc. Metals, Preprint No. 4, Oct., 1941 meeting), described high-phosphorus titanium-bearing steels (0.09-0.11 C, 0.85-1.25 Mn, 0.15-0.25 Si, 0.10-0.15 P, 0.45-0.60 Cu and 0.40-0.60 per cent Ti) that were weldable, were tough at 22 deg. F. below zero, and had a yield strength above 50,000 lbs. per sq. in., Izod value above 20 in all conditions of heat treatment, and immunity to temper-brittleness or temper-hardening.

Another low-alloy steel—this time for castings—was reported by Ziegler and Northrup, of Crane Co., in a paper (Preprint 37) at the same meeting. Their steel, developed to meet the specification of 15 ft.-lbs. Charpy value at —150 deg. F., contains 0.05 C max., 0.20-0.50 Si, 0.50-0.80 Mn, 0.03 S max., 0.02 P max., and 3.5-4.0 per cent Ni. Its properties were given as tensile strength greater than 60,000 lbs. per sq. in.; yield strength 40,000 lbs. per sq. in.; elongation 35 per cent; Charpy value 40 ft.-lbs. at room temperature and 20 ft.-lbs. at —175 deg. F.

Non-Ferrous Alloys

A new lead-base bearing alloy announced by Phillips, Smith & Beck of American Smelting & Refining Co. (Am. Soc. Testing Materials, Preprint No. 46, June 1941 meeting) contains 12.5 Sb, 3 As and 0.75 per cent Sn. The new alloy was reported to have better mechanical properties at auto-engine temperatures than the standard lead-base alloy and as good as the tin-base alloy, and to resist softening for long periods of time.

Columbium-bearing copper and copper alloys described by Seybolt, of Battelle, at the October meeting of the A. I. M. E. were found to have higher softening temperatures than columbium-free alloys. Thus, 0.58 per cent Cb raises the softening temperature of cold-rolled copper from 480 deg. F. to 840 deg. F. and of cold-rolled 80/20 cupro-nickel from 930 to 1110 deg. F.

In addition to all the foregoing developments, a number of new alloy compositions were announced or described in feature articles or reports in METALS AND ALLOYS during 1941. Space is lacking to review these completely, but for the reader's reference-convenience we are listing below the issues of METALS AND ALLOYS in which they were presented:

Two new age-hardenable copper-cobalt-silicon alloys —by Hensel, Larsen & Holt of P. R. Mallory & Co., Feb. 1941

Age-hardening copper-nickel alloys containing zirconium and aluminum—by Nippes of Rensselaer, Mar. 1941

Ultra-high-resistivity manganese base alloys—by Averbach of Rensselaer, June and July 1941

A new sintered copper-molybdenum-iron glass-sealing alloy—by Kurtz of Callite Tungsten Corp., Powder Metallurgy Conference Report, Nov. 1941

An internally-oxidized porous iron material—by Lenel of Moraine Products Div., Powder Metallurgy Conference Report, Nov. 1941

A stainless steel powder made by selective corrosion —by Wulff of M.I.T., Powder Metallurgy Conference Report, Nov. 1941

Reference Table of

NEW MATERIALS AND FINISHES OF 1941

Compiled by Fred P. Peters

The products described in this Table are those that have been placed on the market in recent months. Not all are strictly "new" materials or finishes—some are previously developed products in new guises or forms; others were developed in 1940 but received their first important applications in 1941; and still others represent industrially important modifications rather than fundamentally new materials or finishes. Each, however, is of commercial significance because it represents a new product, a new brand name or a new supply source to challenge the engineer's attention.

Raw material stringencies and the current overwhelming acceleration of the war production effort have caused some of the listed products to be withdrawn from the general market. But we have set down "for the record" all the new proprietary materials and finishes we could unearth, and readers who keep these annual compilations from year to year will thus have a continuing record of new-material developments—through the war-period and beyond.

The statements appearing in the Table are based on the claims of the manufacturers concerned and do not necessarily constitute either a recommendation by this magazine of any products listed or agreement with the claims expressed. However, every effort has been made to include only factual information.

The Table is divided into 8 sections, as follows:

1. Engineering and Machinery Steels
2. Tool Steels and Tool Materials
3. Iron-Base Alloys
4. Non-Ferrous Alloys
5. Powder Metallurgy Products
6. Non-Metallic Materials
7. Finishes and Coatings
8. Welding Rods

Within each section the products are arranged alphabetically by trade names.

Type of Material	*Trade Name or Designation*	*Nominal Composition*	*Outstanding Features*	*Applications*	*Manufacturer*
Engineering and Machinery Steels	Drever—Industrial surface-hardened stainless steel	Stainless steel, exposed at high temp. to "ionized" ammonia gas	High hardness (about 1000 Vickers Brinell) and wear resistance combined with good corrosion resistance	High-pressure steam valve seats, oil-well pumps, plungers, power transmission roller chains, engine liners and valves, etc.	Industrial Steels, Inc., Cambridge, Mass., and The Drever Co., Philadelphia
	Elastuf 44, heat-treated	Cr-Ni-Mo steel	Uniform cross-sectional hardness of 44-46 Rockwell C; high impact strength; commercially machinable	Gears, worms, pinions, gudgeons, short shafts for high torque and wear resistance	Horace T. Potts Co., Philadelphia, and others
	Jessop Non-Magnetic	Very-high-alloy	Free-machining; low magnetic permeability and high electric resistance; good tensile strength and toughness	Electrical applications — transformer housings, switch covers, spacing bars, etc.	Jessop Steel Co., Washington, Pa.
	Manganal	11-13.5 Mn 3.5 Ni	Austenitic, non-magnetic, abrasion-resisting, weldable steel plate. Tensile strength up to 150,000 lbs./in.^{2} Requires no heat treatment after hot punching or forming	Electrical applications; for repairing broken parts; in conjunction with castings for "composite" welded structures	Jos. T. Ryerson & Son, Inc., Chicago
	N-A-X 9100	0.08-0.70 C 0.60-0.75 Mn 0.60-0.90 Si 0.0-0.20 Mo 0.10-0.20 Zr	A general purpose steel, properties controllable by varying carbon and molybdenum contents. Can be (1) low-alloy, high-tensile steel; (2) carburizing steel; (3) constructional steel	Used as mild alloy steel wherever optimum impact and fatigue values are required; as carburizing grades of controlled hardenability for gears, pins, shafts, etc.; structural grades may replace highly-alloyed steel	Great Lakes Steel Corp., Ecorse, Mich.
	Otiscoloy	0.12 C 1-1.35 Mn 0.10-0.14 P 0.50 Cu	Low-alloy, high-tensile steel. 70,000-85,000 lbs./in.^{2} tensile strength, 50,000-70,000 lbs./in.^{2} yield strength, 30% elongation, high endurance limit. Good weldability and corrosion resistance	Structural applications on mobile equipment, auto frames, railroad cars, trucks, etc.	Otis Steel Co., Cleveland
	S.A.E. 4815	0.15 C 3.5 Ni 0.25 Mo	A carburizing steel, providing high core strength and high hardness	Heavy duty gears, splined shafts, pinions, etc.	Jos. T. Ryerson, Inc., Chicago and others

Type of Material	*Trade Name or Designation*	*Nominal Composition*	*Outstanding Features*	*Applications*	*Manufacturer*
Engineering and Machinery Steels	Super-Scottsonizing	Surface-hardened stainless steel	High hardness and wear resistance combined with good corrosion resistance	Parts that must resist both corrosion and wear	C. U. Scott & Son, Rock Island, Ill.
	Union Maxcut	Low-C Bessemer steel	A free-machining steel, with properties and heat treating behavior like S.A.E. X1112	For applications requiring fastest machining	Union Drawn Steel Div., Republic Steel Corp., Massillon, Ohio
	Union Multicut	Low-C O. H. steel	A free-machining steel, with properties similar to S.A.E. 1115. Can be carburized and hardened to 60 Rockwell C	For applications requiring fast machining, low distortion on heat treating, good properties in case and core	
Tool Steels and Tool Materials	66 High Speed	0.80 C 4 Cr 5 Mo 5.5 W 1.6 V	Low-tungsten high speed tool steel; has tool life comparable to 18-4-1	For general purpose high speed cutting tool applications	Bethlehem Steel Co., Bethlehem, Pa.
	883 Hot Die	0.40 C 5 Cr 1.3 Mo 0.4 V	Hot hardness and toughness	Tools for hot forming of metals	Carpenter Steel Co., Reading, Pa.
	FCC Composite Tool Blanks	High speed steel cutting surface welded to mild steel base	Reduces tendency to crack at dovetail corners during heat treating or working; saves high speed steel	For dovetail cutters for screw machines	The Forging & Casting Corp., Ferndale, Mich.
	Graph-A1	1.50 C 0.20 Al, free graphite	A water-hardening graphitic tool and die steel. Good machining properties; high hardness after heat treatment; non-scoring	Tools, dies and parts subject to impact in service	Timken Roller Bearing Co., Canton, Ohio
	Graph-MNS	1.50 C 1.25 Mn 1.75 Mo 1.25 Si, free graphite	An air-hardening graphitic tool and die steel. Good machinability and wear resistance in service; non-scoring	Tools, dies and machine parts requiring very high impact resistance	
	H. M. High Speed	0.71-0.84 C 3.60 Cr 8 Mo 1.6 W 1 V	Low-carbon grades combine toughness and hardness; high carbon provide exceptional hardness. Performance is equivalent in many ways to 18-4-1	For general-purpose cutting-tool requirements, and for both cold and hot die applications	Bethlehem Steel Co., Bethlehem, Pa.
	Jessop 773	Medium-C Mn-Mo steel	High toughness, rigidity in thin sections when hardened	Step-down dies, spatulas, putty knives, as well as general tools, dies, punches, etc.	Jessop Steel Co., Washington, Pa.
	Kennametal K3H	Tungsten titanium carbide	Cemented carbide tool tip material with high hardness and toughness	Tool tips for light finishing cuts or heavy continuous cuts on hardened steel	McKenna Metals Co., Latrobe, Pa.
	Kennametal K4	Tungsten titanium carbide	Cemented carbide tool material with high strength (223,000 lbs./in.^{2}) and hardness (92 Rockwell A)	For machining hard crumbly materials like cast iron, plastics, aluminum alloy, bronze, etc.	

Type of Material	Trade Name or Designation	Nominal Composition	Outstanding Features	Applications	Manufacturer
Tool Steels and Tool Materials	Red Tiger	1 C 18 W 4 Cr 2.5 V 0.70 Mo	A high speed steel; has 65-68 Rockwell C hardness after heat treatment, and shock resistance comparable to 18-4-1	For rough- and finish-machining of heat treated car wheels, axles, alloy steel gears, iron castings, etc.	Bethlehem Steel Co., Bethlehem, Pa.
	Sinta-Set	Industrial diamonds set in tungsten carbide matrix	Highest wear resistance, longer drill life, dimensional accuracy, no recondiitoning of diamond bits	Core bits for rotary drilling equipment	Carboloy Co., Inc., Detroit, Mich.
	Speed Star Molybdenum	0.80 C 4 Cr 5.5 W 4.25 Mo 1.5 V	A low-tungsten high speed steel. Has high hardness both hot and cold	General high speed cutting tool application	Carpenter Steel Co., Reading, Pa.
	Star J-Metal	Co-Cr-W alloy	Modification of former J-Metal; improved tool life between grinds. Intermediate between cemented carbides and high speed steels.	For general machining of cast iron, steel, etc.—particularly difficult jobs	Haynes Stellite Co., Kokomo, Ind.
	Star-Mo	6 W 6 Mo 1.5 V	Low-tungsten high speed steel, performance comparable to 18-4-1; good all-round working and treating properties	For high speed cutting tool applications and for dies	Firth-Sterling Steel Co., McKeesport, Pa.
	Windsor	Cr-Mo-V steel	Non-deforming, with high toughness, wide hardening range and easy machining; low cost	Punching tools and dies, forming dies, etc.	Jessop Steel Co., Washington, Pa.
Iron-base Alloys (See also Powder Metallurgy Products)	Alchrome 3	83 Fe 14 Cr 3 Al	Nickel-free resistance alloys, capable of performing at moderately high temperatures	Resistance wire and ribbon for toasters, hot plates and electric appliances generally	Wilbur B. Driver Co., Newark, N. J.
	Alchrome 6	74 Fe 20 Cr 6 Al			
	Hipersil	Silicon-steel with controlled crystal orientation	A silicon steel of extra-high magnetic permeability. Flux-carrying capacity is ⅓ greater than usual silicon steel. Lower magnetostriction	Transformer core construction, particularly where reduction in size or weight is desired	American Rolling Mills Co., Middletown, Ohio, and Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
	Vicalloy	30-52 Fe 36-62 Co 6-16 V	Permanent magnet alloy with very high $(BH)_{max.}$; can be drawn and rolled	Permanent magnets, magnetic tape, etc.	Bell Telephone Labs., New York

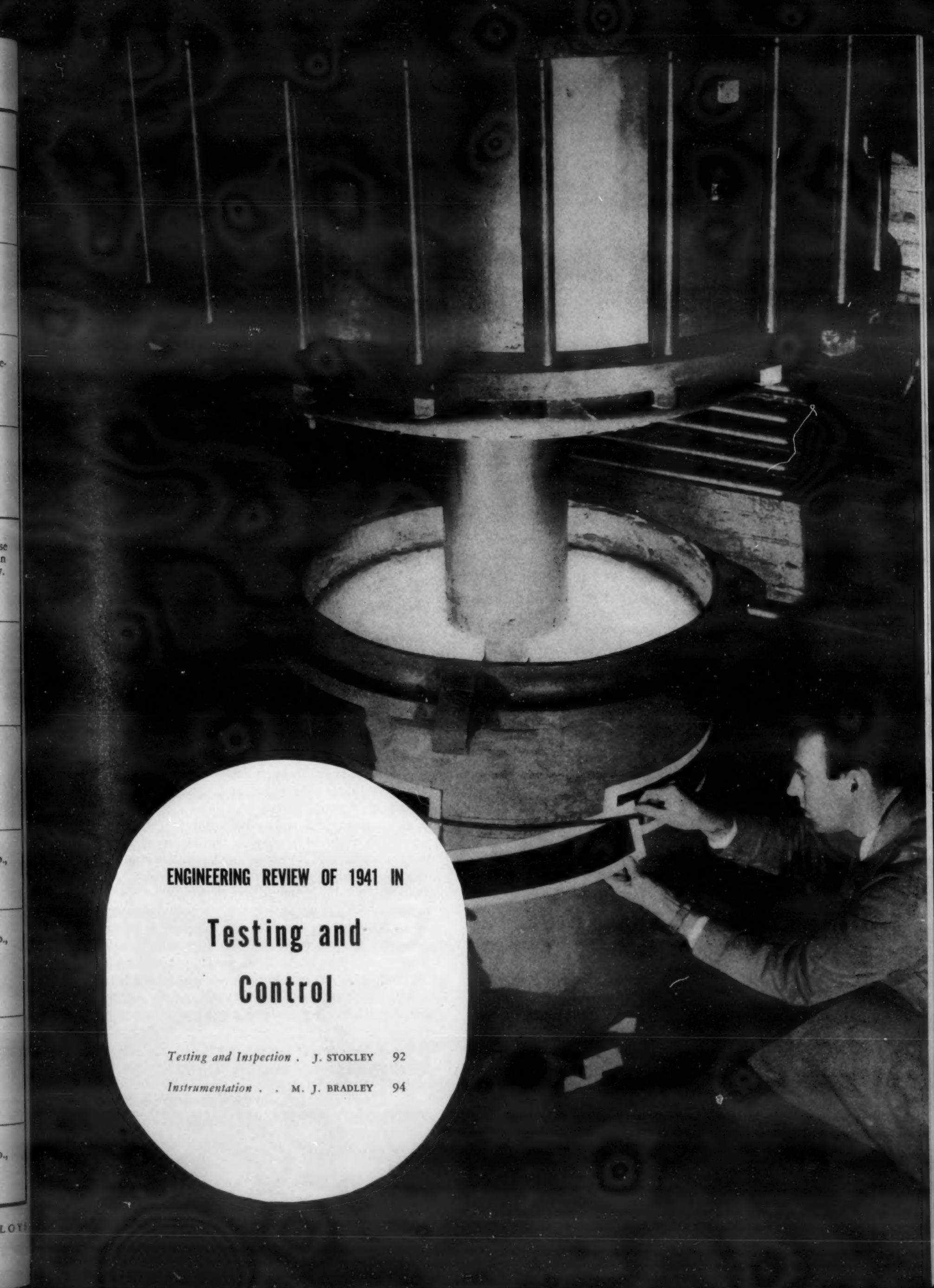
Type of Material	Trade Name or Designation	Nominal Composition	Outstanding Features	Applications	Manufacturer
	Ajax "Navy" Tombasil	91 Cu 4.5 Si 4.5 Zn	Silicon "bronze" casting alloy. Greater strength than 88-10-2 and 88-10-4 bronzes or straight copper-silicon alloy. Good casting properties, fine grain and corrosion resistance	For large or small castings of sound, homogeneous structure, high strength and corrosion resistance	Ajax Metal Co., Philadelphia
	Ampco Metal 20-13	Cu-Al-Fe alloy	An iron-containing aluminum bronze, specially heat treated. High hardness (200 Brinell) combined with good ductility, corrosion-resistance and abrasion resistance. Excellent bearing properties	Bushings and bearings against hardened steel shafts; cylinder liners, plungers, pump parts, etc.	Ampco Metal, Inc. Milwaukee, Wis.
	Hytensil Casting Alloy	Aluminum alloy	Strong aluminum alloy for use, particularly in castings, without heat treatment. Tensile strength 33,000-40,000 lbs./in.^{2}, elongation 6%, hardness 70-80 Rockwell E, as-cast	Aircraft castings and to replace hard-to-get forgings, extrusions, etc.	Hytensil Aluminum Co., Chicago
	"KR" Monel	66 Ni 29 Cu 2.75 Al 0.25-0.35 C	Corrosion-resistant alloy that is free-machining and can be age-hardened to high strength values; non-magnetic	Machined products calling for both corrosion resistance and high strength	The International Nickel Co., Inc., New York
Non-Ferrous Alloys (See also Powder Metallurgy Products)	Monarch Metal	High-lead-copper-tin alloy	Leaded bronze, featuring uniform, fine dispersion of lead in the structure, resistance to galling and seizing, high hardness and wear resistance	Bearings and seals	Monarch Alloys Co., Ravena, Ohio
	Nada "C"	95.75 Cu 3.25 Si 1.0 Sn	A corrosion resistant bronze possessing high strength and good ductility	Sand castings	Nassau Smelting & Refining Co., New York
	Roofloy	Lead sheet contg. 0.02 Ca 0.02 Mg 0.25 Sn	High strength and improved creep resistance (10 times that of ordinary sheet lead)	Sheet roofing; can be used in thinner and lighter sheets because of its higher strength	Revere Copper & Brass, Inc., New York
	Silver Laminates	Silver laminated to base metals	Good conductors; strong; excellent contact behavior; corrosion resistant; low cost	Wire, flatstock, tubing, etc. — to replace copper, or where both corrosion resistance and rigidity are required.	General Plate Div., Attleboro, Mass.
	T-1	Aluminum alloy contg. Ti and Mg	Aluminum alloy, particularly for castings, that gives 33,000 lbs./in.^{2} tensile strength, 6-10% elongation and Brinell hardness of 60-78 without heat treatment. Good machinability and corrosion resistance	Sand and permanent mold castings for aircraft engine parts, diesel equipment, etc. —also available as ingots	National Bronze & Aluminum Foundry Co., Cleveland
	Tube-Loy	Lead tubing contg. 0.02 Ca 0.02 Mg 0.25 Sn	High strength lead; withstands 125 lbs. pressure	Tubing for water service and conveying gas and oil. Permits use of lighter-weight tubing structures	American Smelting & Refining Co., New York

Type of Material	*Trade Name or Designation*	*Nominal Composition*	*Outstanding Features*	*Applications*	*Manufacturer*
Powder Metallurgy Products	Durex Iron	98 Fe 2 C	Porous material pressed from iron powder. Is self-lubricating, hard, strong, stable and wear-resistant	For bearings, machine parts, cams, gears, etc., where powder metallurgy design is advantageous and machining is to be practically eliminated	Moraine Products Div., General Motors Corp., Dayton, Ohio
	G-A-W Carbonyl Iron Powder	Highly pure iron powder, free from Si, P, S and Mg	Iron powder of the maximum purity and high apparent density (4.6 g./cc.). Particles are spheroidal and sintering properties excellent	Electrical applications, radio magnetic cores (and shields) for permeability tuning, etc., and high purity iron parts generally	Advance Solvents & Chemical Corp., New York
	Gempco	Mixtures of heat-conducting and wear-resistant materials	Friction materials, possessing a combination of structural strength, heat conductivity and abrasion resistance	Facings and linings in aircraft, automobiles, trucks, machinery, etc.	General Metals Powders Co., Akron, Ohio
	Gibsiloy Grade NW	Silver-nickel-tungsten	Pressed and sintered "compound" materials; arc resisting, hard, non-sticking; low contact resistance	Heavy duty contacts for relays, motor starters, etc.	Gibson Electric Co., Pittsburgh, Pa.
	Iron-Oilite	Chiefly iron	Porous iron of good mechanical properties, pressed from metal powders	For machine parts, particularly irregular shapes produced without subsequent machining	Chrysler Corp., Amplex Div., Detroit, Mich.
	Plast-Iron Powder	99.5% Fe	Electrolytic iron powder of "chemical" purity, uniformity, and satisfactory pressing characteristics	For making high-density, high-purity compacts, magnets, tuning cores, etc.	Plastic Metals, Inc., Johnstown, Pa.
	Plast-Sponge Powder	95.98% Fe	Sponge-iron type powder, soft, non-abrasive, free-flowing, highly compressible.	For making iron compacts for machine parts	
	Pomet 111	5-10 Sn bal. Cu	Low-porosity bronze material pressed from powders. Properties equivalent to those of cast bronze. Excellent wear-resistance	Mechanical and electrical parts, where elimination of machining or other advantages of powder metallurgy manufacture may be welcome	Powder Metallurgy, Inc., Long Island City, N. Y.
	Pomet 300	High-purity iron	High permeability, etc. for magnet cores, pole pieces, etc.		
	Pomet 389	0.1 C bal. Fe	Low-porosity steel-like material pressed from powders. Equivalent to cold-rolled steel; excellent wear properties		
	Pomet 560	Aluminum Alloy	Equivalent to cast aluminum		
	Porex	92 Cu 8 Sn	Controlled-porosity filtering material, pressed from metal powders. Has adequate strength and good corrosion resistance	In devices for filtering, diffusing or metering fluids, gases, air, etc. in process industries, automotive equipment, power units, etc.	Moraine Products Div., General Motors Corp., Dayton, Ohio

Type of Material	*Trade Name or Designation*	*Nominal Composition*	*Outstanding Features*	*Applications*	*Manufacturer*
Powder Metallurgy Products	Sinterloy	Carbon-iron alloy powder	A steel-like powder of variable carbon content for the manufacture of high-strength "steel" parts by powder metallurgy	For making machine parts, small hardware, etc.	Chas. Hardy, Inc. New York
	Super-Oilite	Iron-copper	High strength porous material possessing heat conductivity and wear resistance. Capable of supporting heavy bearing loads	Heavy duty bearings	Chrysler Corp., Amplex Div., Detroit, Mich.
	Velvetouch	Cu-Pb-Sn-graphite and other mixtures	Sintered friction materials possessing good heat conductivity, resistance to high temperatures, uniform friction properties, strong construction	Clutch and brake disks, friction clutches, linings, facings, machinery bearings, etc.	S. K. Wellman Co., Cleveland
	Steel powder	High-C-Ni-steel powder	Makes high-strength, heat-treatable compacts	For making machine parts of various types	Powder Metals & Alloys, Inc., New York
Non-Metallic Materials	Durez 77S	Phenol formaldehyde plastic	Low water absorption; extra-smooth finish; acid, alkali and wear resistance	General purposes	Durez Plastics & Chemicals, Inc., No. Tonawanda, N. Y.
	Durez 1900 and 1905	Phenol formaldehyde plastic	High impact strength	Heavy duty moldings	
	Durez 1910	Phenol formaldehyde plastic; contains graphite	Good strength, relatively high conductivity, excellent friction properties	Bumper shoes, lock bolts, etc.	
	Haveg	Phenolic resin plus asbestos	Acid and alkali-resistance, good mechanical strength	Pipes, fittings, valves, tanks, pickling equipment, etc.	Haveg Corp., Newark, Del.
	Pregwood	Wood impregnated with phenolic resin	High physical values, design flexibility, ease of fabrication	Aircraft structures	Formica Insulation Co., Cincinnati, Ohio
	Saran	Vinylidene chloride plastic	A group of plastics ranging from flexible, semi-transparent tubing material to a hard, tough thermoplastic with tensile strength of 60,000 lbs./in.^{2} Very corrosion resistant	Tubing, formed parts, etc.; can replace metal parts, except under high-temperature or high-pressure conditions	Dow Chemical Co., Midland, Mich.
	Tygon	Synthetic rubber-like material	Physically resembles rubber; corrosion resistance like that of chemical stoneware (also, resists hydrochloric acid). May be formed into resilient tubes, stiff sheet, molded products and extruded shapes	Molded corrosion-resistant products; linings for pickling, plating and cleaning tanks; surface coatings for protective films	United States Stoneware Co., Tallmadge, Ohio
	Vulcoid	Phenolic resin plus vulcanized fibre	Relatively high strength, ease of fabrication, moisture-resistance, and high electrical insulating value	Electrical and mechanical insulating and structural parts	Continental Diamond Fibre Co., Newark, Del.
	Vycor Nos. 790 and 792	96% silica glass	Low expansion (8×10^{-7}), high softening point, resistance to acids, alkalies and heat	Process industry equipment, laboratory apparatus, etc.	Corning Glass Works, Corning, N. Y.

Type of Material	*Trade Name or Designation*	*Nominal Composition*	*Outstanding Features*	*Applications*	*Manufacturer*
Finishes and Coatings	Bon White	Tin coatings, by immersion, on copper and brass	Quick-immersion process, in which proprietary paste is added to sodium cyanide solution. Pure tin coating is white, highly tarnish-resistant	For rapid manufacture of tin-plated products requiring high tarnish resistance	Alrose Chemical Co., Providence, R. I.
	Colorbond	Galvanized sheet with paint-bonding surface	Surface finish metallurgically modified to provide direct bond for paint coatings, with consequently improved adherence. Protectiveness equal to that of conventional galvanizing	Where galvanized sheet is to be painted. Available on steel, copper-bearing steel and other bases	Newport Rolling Mill Co., Newport, Conn.
	Corronized Steel	Composite electrodeposits Ni-Zn, Ni-Sn, Ni-Cd, etc.	Gives equivalent protection with thinner coatings; saves strategic metals; offers improved corrosion resistance	For protective coatings generally	Standard Steel Spring Co., Coraopolis, Pa.
	Ebonol-Z	Blackening process for zinc	An immersion blackening process for zinc or zinc alloy. Gives adherent jet black finish after 1-5 min. at 150-212° F.	Blackening die cast name plates and recessed etchings; reducing glare of armament products; used for all zinc products, including galvanized steel	Enthone Co., New Haven, Conn.
	Electrodize	A.c. anodic coatings on aluminum and its alloys	Dense coat; increased production volume; universal for all aluminum alloys	For aluminum parts required to have corrosion protection or abrasion resistance. Serves as a paint base	Colonial Alloys Co., Philadelphia
	Electro-Ebonol	Electro-blackening process	Harder, blacker and more adherent than the usual black nickel. Operated at 140-190° F.	For blackening aluminum, steel, stainless steel, zinc, cadmium, nickel, silver, gold, lead, tin, etc.	Enthone Co., New Haven, Conn.
	Electro-Jetal	Electro-blackening process for copper	Anodic blackening process; velvety black surface that readily absorbs oil, wax or lacquer. Comparable in protective value to ordinary nickel plate	Can be used on copper or on any metal that can be first copper-plated	Alrose Chemical Co., Providence, R. I.
	Houghto-Black	Blackening process for steel	An immersion blackening process that in a few minutes gives steel parts a lustrous black finish without alteration of dimensions. Operating temperature, about 290° F.	Steel parts for ordnance, machinery and other uses where a black rust-resistant surface is required	E. F. Houghton & Co., Philadelphia
	Indium Plate	Electro-deposited indium coatings	Decorative, bright metal finish. Soft, but corrosion-resistant	For replacing hard-to-get nickel and chromium plated finishes on a variety of products	Indium Corp. of America, New York American Smelting & Refining Co., New York
	Paintgrip	Galvanized sheet with special "Bonderized" surface	Corrosion-resistant; can be painted immediately. Phosphate film is neutral to paint.	For galvanized sheets that are to be painted	American Rolling Mill Co., Middletown, Ohio

Type of Material	*Trade Name or Designation*	*Nominal Composition*	*Outstanding Features*	*Applications*	*Manufacturer*
Finishes and Coatings	Roxaprene	Synthetic organic finish	Corrosion-resistant; fast-drying	In place of galvanized coatings, where suitable	Roxalin Flexible Lacquer Co., Elizabeth, N. J.
	Unichrome	Alkaline copper-plating process	Rapid; produces smooth, fine-grained copper deposit, even in heavy thicknesses	Ideal as a base for bright nickel plating; permits a reduction in the amount of nickel used	United Chromium, Inc., New York
	Weisberg Bright Copper	Bright copper-plating process	Bright copper-plating for heavy copper deposits, using copper sulphate, diethylene triamine and ammonium sulphate	To save nickel, by using heavy bright copper under plates followed by light nickel coatings	Hanson-Van Winkle-Munning Co., Matawan, N. J.
	Zincgrip	Galvanized sheet with zinc specially bonded	Unusually good adherence of zinc coating. Corrosion-resistant	Wherever severe forming makes ordinary galvanized sheet metal unsatisfactory because of peeling	American Rolling Mill Co., Middletown, Ohio
Welding Rods	Amsco Mo-Mang	Mn-Mo steel	Free-flowing, very tough; work-hardes to 450-500 Brinell. Not recommended where high ductility plus tensile strength is required	Straight build-up welding of worn manganese steel, carbon steel or gray iron parts, such as bucket lips, crusher jaws, etc.	American Manganese Steel Div., American Brake Shoe & Fdry. Co., Chicago Heights, Ill.
	Ampco-Trode	Coated aluminum bronze rod, several grades	Hardness of 60 Rockwell B to 38 Rockwell C; tensile strength, 55,000-96,000 lbs./in.^{2}; 18%-0.5% elongation. Good bearing properties, corrosion resistance	Welding (bronze - welding) steel, cast iron, bronzes, etc. Rebuilding worn cams, gears, dies, bearing surfaces, etc.	Ampco Metal, Inc., Milwaukee, Wis.
	Galv-Weld	Regalvanizing deposit for welds in zinc-coated steel	Galvanizing material in bar form; held against a weld in zinc-coated stock while the latter is still hot, it melts and regalvanizes the otherwise bare weld metal	Applicable to arc, gas and spot welding of galvanized sheets or shapes	Galv-Weld, Inc., Dayton, Ohio
	Harnimoly	Mo steel	High strength (85,000-95,000 lbs./in.^{2}) joints that are machinable and flame-hardenable	Arc welding high-carbon or alloy steels that are to be machined or flame-hardened	Harnischfeger Corp., Milwaukee, Wis.
	Harmomang	Mn-Mo steel	Gives austenitic deposit, of high work-hardenability, toughness and wear resistance	Building-up and resurfacing 11-14% Mn steel parts such as dipper lips, rock-crusher parts, road grading equipment, railway frogs, etc.	Harnischfeger Corp., Milwaukee, Wis.
	Murex Alternex	Coated mild steel rod	Free-flowing, deposits sound, tough metal at high speed; designed for a.c. work	For manual arc welding of light and heavy-gage steel products in all positions, with transformer type a.c. machines	Metal & Thermit Corp., New York
	Planeweld	Shielded-arc special steel electrode	Good for welding S.A.E. 4130 and X4130 steels	Welding aircraft fuselages, torque tubes, engine mounts, landing gear forks, etc.	Lincoln Electric Co., Cleveland



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Testing and Control

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Testing and Inspection

by JAMES STOKLEY

General Electric Research Lab'y., Schenectady, N. Y.

PRESSURE OF THE "VICTORY" PROGRAM has emphasized the need for rapid and accurate methods of testing and inspection in the field of metals and alloys. Details of some of these, which have made their appearance during the past year or 18 months, are given in the following:

Radiography

A number of important developments have been made in the field of radiography during the past year. Outstanding has been the introduction and wide-spread use of million-volt X-rays as a routine method of testing and inspecting metals. Previously radiographic examination of thickness above 3 in., in the case of steel, was limited because of the long exposure time required at lower voltages. With the million-volt apparatus an exposure may be made through 5 in. of steel in 2 mins., compared with an exposure of 3½ hrs. with X-rays of 400,000 volts. With smaller thicknesses the X-ray tube may be placed far back from the job and a large area sprayed at once. The million-volt equipment can radiograph 64 times as great a volume of metal per man hour as can the 400,000-volt apparatus.

Though a number of million-volt outfits have been installed recently, considerably lower voltages continue to be used effectively, especially on aluminum castings. At the Batavia, N. Y. plant of the Doehler Die Casting Corp., for example, an 85-kv. 15-ma. X-ray unit is being extensively used for examination of aluminum die castings with walls not more than ⅜ in. in thickness. These are made fluoroscopically, the X-ray image appearing on the fluorescent screen. This has the advantage of permitting direct visual examination, without the necessity of exposing and developing photographic film.

Considerable progress has been made in the development of microradiography to reveal details of fine structure in metals previously obtained only by micro-photography. An X-ray beam of high intensity with an applied voltage as low as 5,000 volts is used. The method consists of preparing a thin section of the metal, placing it in contact with a special photographic plate and exposing to low-voltage X-ray radiation. The resulting photographic image, which depends upon the varying absorption of X-rays by different parts of the sample, is enlarged up to magnifications as high as 500 times.

A metal shipping container for radium of a new design was developed during the year which cuts down in the weight and cost. The new container uses steel, tungsten, mercury and plastics in its construction where formerly metal powders of tungsten, nickel, copper were used.

Electron Microscope and Micromachines

The introduction of an electron microscope applicable for use in general laboratories was an outstanding development of 1941 for the metallurgical field. The new model is smaller and completely self-contained. It can be operated by any competent laboratory worker. The electron microscope operates very much like an ordinary light microscope, except that instead of glass lenses and light, it utilizes a stream of electrons propelled at high speed through a series of magnetic coils. With this equipment the surface structure of a metal is reproduced in a collodion replica film which in turn is examined in the electron microscope. Electron pictures taken at 20,000 magnifications are possible.

Equipment for physical testing of very small specimens made its appearance in the commercial market recently. The micromachines use specimens of a diameter of 0.060 to 0.079 in., and effective lengths of about 0.312 in. for tensile, shear and flexing tests.

Micromachines have been in existence for a number of years, but were more or less in the experimental stage until this year.

Spectrography

A new method of quantitative spectrographic analysis, which eliminates errors introduced by the

photographic process, has been developed in the general engineering laboratory and the Schenectady works laboratory of the General Electric Co. and described by J. T. Mireles Malpica.

Other methods used up to the present time require a high degree of uniformity in the characteristics of the photographic plate, and controlled exposure and development conditions. Any accidents or unavoidable change are liable to introduce serious errors.

The new method eliminates this restriction and it is actually possible to use two completely different kinds of plates, change the development time by 100 per cent, etc., without the introduction of serious errors. It is scientifically sound, and capable of a high degree of accuracy, increasingly necessary in modern analysis.

During the past year an electronic spark generator has been developed which is coming into extensive use. A capacitor is charged periodically with a single impulse of "measured" electrical quantity, and the controlled discharge used as a source of excitation.

Since it is entirely electronic, the new circuit eliminates the difficulties of other apparatus, using a rotating spark gap, the electrodes of which corrode; it is subject to other faults.

Hardness Testing

Interest in micro-hardness testing continued high during 1941. The Hanemann micro-hardness tester, developed in Germany, is now being manufactured in this country and utilized to an increasing extent. Particular attention was given to its potentialities for hardness testing of porous powder metallurgy products and of multi-phase alloys in general.

Work was done on the hardness testing of very thin, brittle or shallow surfaces and a new method of determining the Knoop hardness number was developed. The Tukon tester is used which employs minute high precision penetrators and an optical measurement of indentation.

Impact and Creep Tests and Stress Analysis

At the Philadelphia meeting of the American Society for Metals, in October, E. R. Parker and Catherine Ferguson, of the General Electric Research Laboratory, reported their studies of the effect of strain rate upon the tensile impact strength of some metals. The object of the investigation was to determine how much energy metals could absorb at high strain rates. A variable velocity impact machine was used. It was found that most of the metals tested could absorb more energy during breaking when hit quickly than when slowly pulled apart.

Tests of the bursting speed of rotors were made by K. D. McMahan and Frank Quinlan, of the General Electric Research Laboratory, using a vacuum chamber. Because windage is eliminated, a small compressed air turbine, developing about a horsepower, is sufficient to drive the rotors up to speeds in excess of 50,000 rpm.

Use of the vacuum also permits a stress coat analysis, at speeds below the rupture point. The part to be tested is coated with a brittle varnish. During the run the part expands and cracks the varnish, the crack being retained after the stress is removed. Cracks form at right angles to the stress and their numbers is proportional to its magnitude. Thus a definite indication of the amount and direction of stress is formed at every point on the test piece.

A method of "accelerated creep" tests for metals was described by Dr. Saul Dushman, of the General Electric Research Laboratory, to the American Society of Rheology in October, whereby a thin wire of the metal is used and heated to glowing, from 1500 to 2000 deg. F. by an electric current. The wire is enclosed in a glass cylinder, through which nitrogen flows to prevent oxidation. A hanging weight exerts the stress, and the extension of the lower end of the wire is measured with a cathetometer. The lengthening is of the order of 0.5 per cent per hour, and considerable data on high rates of creep may be obtained in a day or two.

Fatigue and Corrosion Tests

A new machine for rapid determination of the endurance limit of steels at high temperatures was developed by Welch and Wilson, Westinghouse Elec. & Mfg. Co. The specimen is stressed in alternating bending at a frequency of 120 cycles per second and is driven at constant amplitude by reciprocating electromagnetic motor. Since the machine operates very close to resonance, an electronic control is provided to maintain constancy of amplitude.

An accelerated atmospheric corrosion test was reported by H. Pray, Battelle Memorial Institute, and J. L. Gregg, Bethlehem Steel Co. Test procedure and equipment have been developed which are capable of predicting in a few weeks the relative atmospheric corrosion rates of ordinary and low-alloy steels.

Gages—Strain and Thickness

Electric strain gages of the type developed by Ruge and de Forest were improved this year. First introduced in 1940, the improvements include the development of a temperature compensated gage for application to curved surfaces and an improved strain rosette for two-dimensional stress analysis. With this apparatus it is possible to read static strains down to 15 lbs. per sq. in. in steel and frequencies to over 30,000 cycles per sec. The "Celstrain" gages which

are of the same type have added the advantage of remote reading and vibration insensitivity.

Hardenability Tests

Two important developments occurred for determining hardenability of steels. The use of the "Wuerfel bomb," which is a conical-shaped piece of steel having a hole concentric with the axis of the cone, was introduced by McCleary & Wuerfel of Chrysler Corp. In use, the test piece is put into the hole of the bomb and the assembly heated to the desired temperature and quenched in water. The test-piece is removed and hardness readings are taken.

O. V. Greene and C. B. Post of the Carpenter Steel Co. attacked the problem presented by shallow-hardening steels. Their test specimen consists of a tapered round bar having a taper of 1 in. in 5 inches. The test incorporates concepts of cooling velocities through a given temperature and of critical bar diameter at a given severity of quench, and permits correlation of other tests with one another.

Instrumentation

by M. J. BRADLEY

Market Extension Div., Leeds & Northrup Co., Philadelphia

TO KEEP PACE with today's urgent needs for improvements in manufacturing methods, new and improved instruments are constantly becoming available to increase convenience, reliability and accuracy. These benefits are also derived from improved methods of applying existing instruments. By coordinating control of all variables in a process, the desired result is becoming a certainty within ever decreasing limits. There is a definite trend toward control from the end result rather than from intermediate conditions. In temperature control, for instance, control can now be based on measurements of work temperature rather than on measurements of furnace temperature.

The Work-Temperature Principle

Development of the radiation pyrometer has greatly increased the possibilities of applying control on the work-temperature principle. Successful results from heat-treating furnaces, rolling mill reheating furnaces, etc., have demonstrated, during the past few years, the close control and high uniformity obtainable when work temperature detected by a radiation pyrometer, rather than furnace temperature, is the basis for control.

Tests on slab and billet furnaces showed that when furnace temperature was held constant, work temperature fluctuated several hundred degrees when work was discharged from the furnace. These variations were caused mostly by changes in mill activity, particularly when the furnace was operated at a higher temperature than the discharged work.

To control furnace temperature from work temperature, it was first necessary to measure work temperature accurately. Application of a thermocouple to the moving work was not practical and radiation measurements were affected by flame, smoke and reflected radiation. The obstacles which interfered with radiation measurements have been largely overcome by the use of a special sighting tube designed for these applications. The temperature detecting element, located outside of the furnace, is sighted through a metal or ceramic tube which projects through the top of the furnace toward the slab or billet which is about to be discharged. A shade on the end of this tube eliminates reflected radiation from surrounding flame and furnace walls. Gas or air, introduced into the tube near the pyrometer, causes a slight down draft which prevents the entrance of smoke.

When control of temperature is based on measurements taken under these conditions the desired temperature uniformity of the cakes coming from the furnace is obtained in spite of the presence of variations in mill demand. As may be expected, the

actual furnace temperature fluctuates widely to produce this work uniformity.

In Blast Furnace Operation

While the successful operation of blast furnace stoves depends upon the temperature of the checker bricks, it has been customary to measure gas temperatures and calculate checker-brick temperatures on the assumption that there was a fixed relationship between the two. Experience has shown that this relationship is actualy variable and the method accordingly inaccurate.

A radiation temperature detector sighted on the top surface of the checker-bricks provides an accurate means of attaining actual checker-brick temperatures. A sighting tube, kept clear by a slight draft of air, is installed in the center of the stove dome. The radiation temperature detector, located outside of the stove, sights directly on checker-bricks. The sighting tube is so installed that, if the radiation detector is removed for maintenance purposes, a valve can be closed against the pressure conditions existing within the stove.

From the knowledge of actual checker brick temperatures, the heating-up cycles may be accomplished at optimum temperatures for maximum efficiency and minimum loss of brickwork due to overheating.

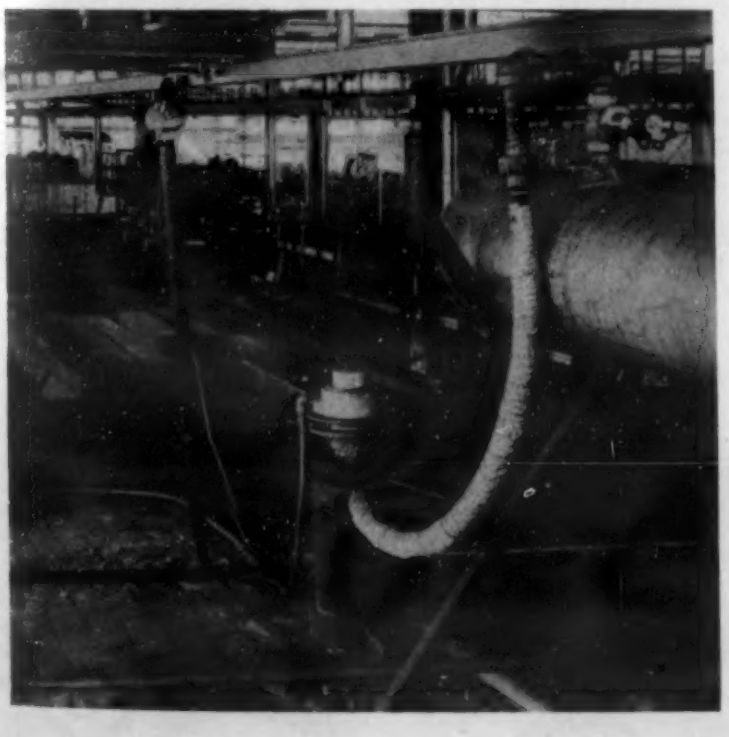
In Sheet, Strip and Other Mills

One of the most spectacular applications of the radiation pyrometer to work temperatures is its use on sheet, strip, rail, slab and pipe mills. The detecting element is permanently installed, usually in a water-cooled jacket above the work. The temperature of the passing work is indicated and recorded on a high-speed recorder. So responsive is this instrument that usually even temperature variations along the length of the hot object are recorded. With this information, initial temperature and roll speed can be so adjusted that the finishing temperature will be as required. Each piece can be finished at the same temperature to gain the physical characteristics specified.

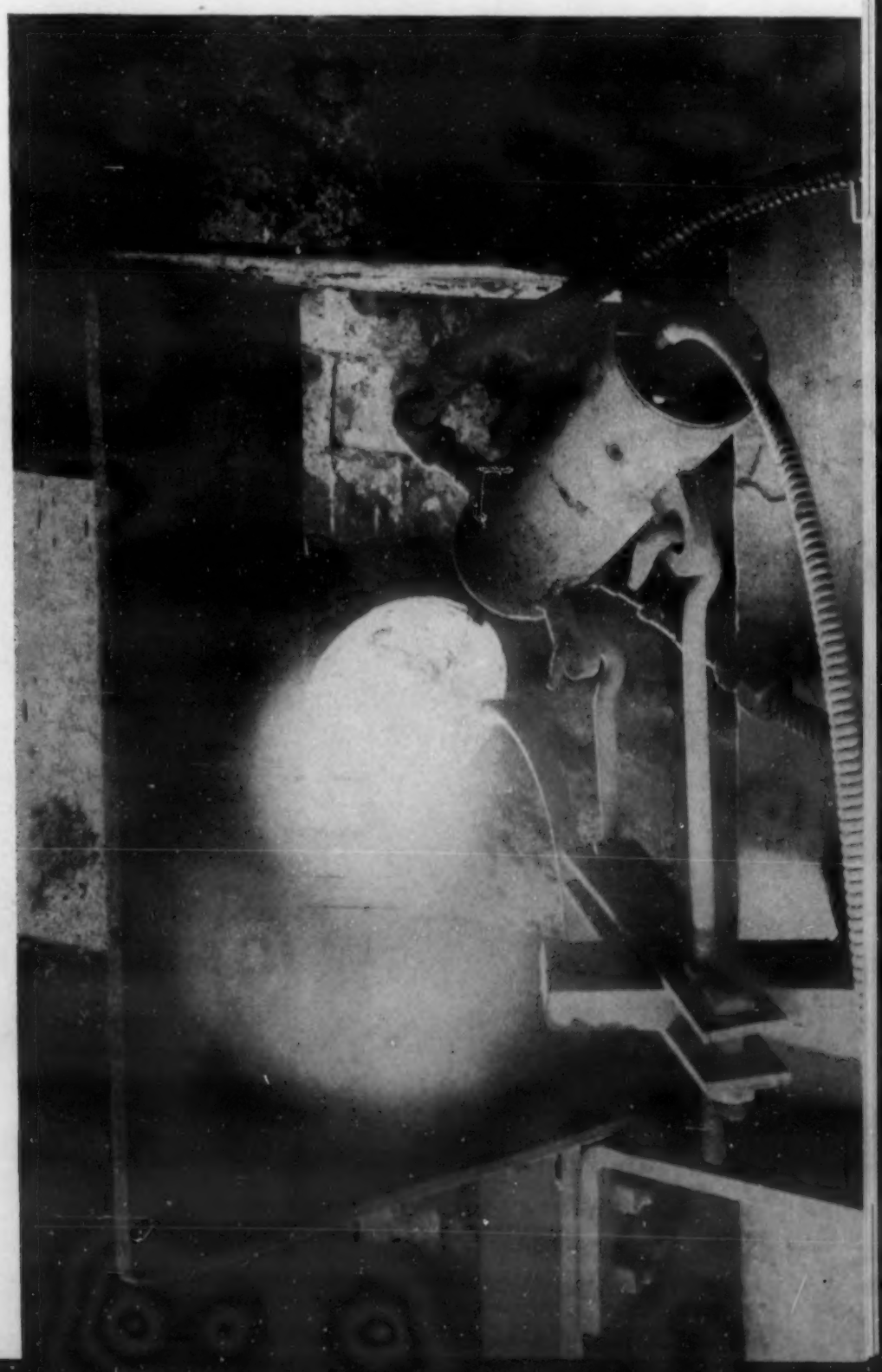
While highly useful on any mill, this application of control from work-temperature is particularly valuable where steels or non-ferrous metals of special analysis must finish to exacting specifications—where rolling expensive melts at the *correct* temperature eliminates costly rejections.

Applications of control by work-temperature in continuous heat-treating furnaces not only insure a highly uniform output, but contribute to lower operating costs. Installations are similar to those for slab and billet furnaces except that the shade is usually not necessary. The radiation detecting ele-

Radiation pyrometer element located on top of slab-heating furnace for temperature control.



Taking the temperature of the inside surface of the roof of an open-hearth furnace with a radiation pyrometer element



ment sights directly on the moving work, allowing furnace temperature to vary so that work-temperature is constant.

Savings in fuel or electricity result from knowing work-temperature exactly. There is no necessity for keeping the furnace hotter than it need be just to be sure the work-temperature will be high enough to insure proper hardening. Guesswork is eliminated and the furnace is operated at minimum temperature requirements. Use of a radiation pyrometer eliminates thermocouple maintenance and replacement costs, it being outside the furnace and not subject to excessive temperature. It is also unaffected by any "atmosphere" gas required in the process.

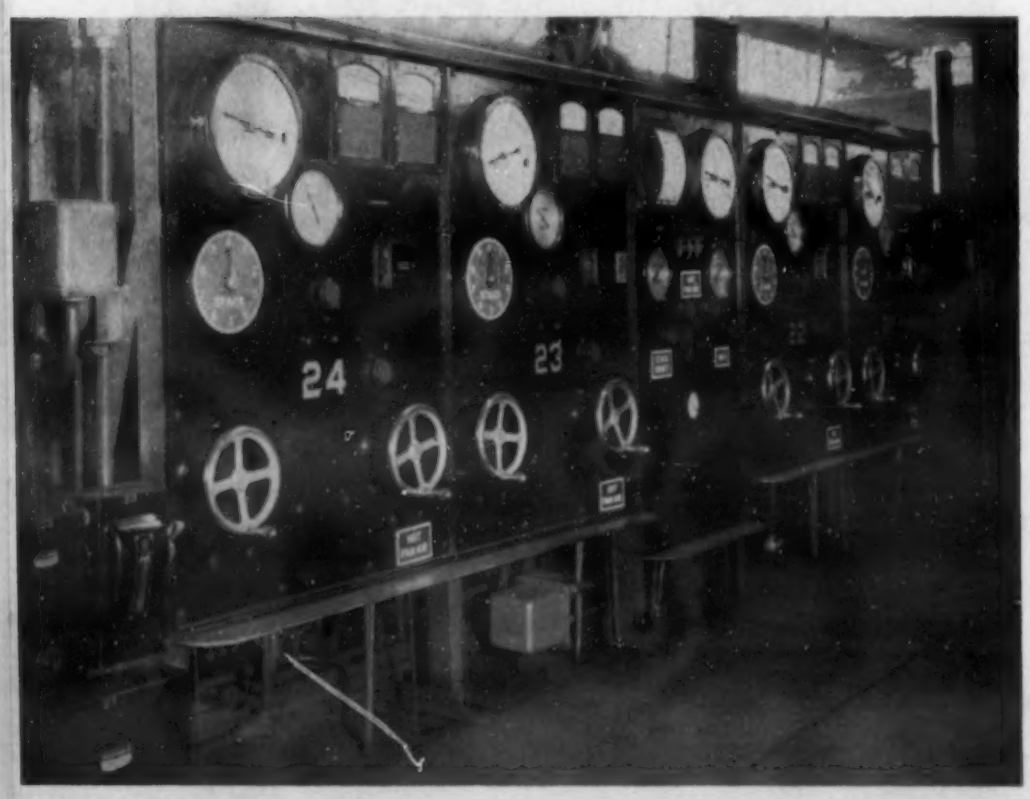
Control for Open-Hearth Furnaces

The open-hearth furnace probably offers the greatest opportunity for co-ordinating the control of many factors, because in few other processes does the final product depend upon so many and such varied elements. In view of this, it is practically impossible for the first helper to make continuously the great number of adjustments required to maintain favorable conditions of combustion, furnace pressure, reversing and roof temperature. While no quantity or condition can be controlled automatically which cannot be controlled manually, and while accurate measurement must, in general, precede accurate control, by coordinating various controls both with the function they must perform individually and as an interrelated part of the whole, better steel is being made today with greater surety.

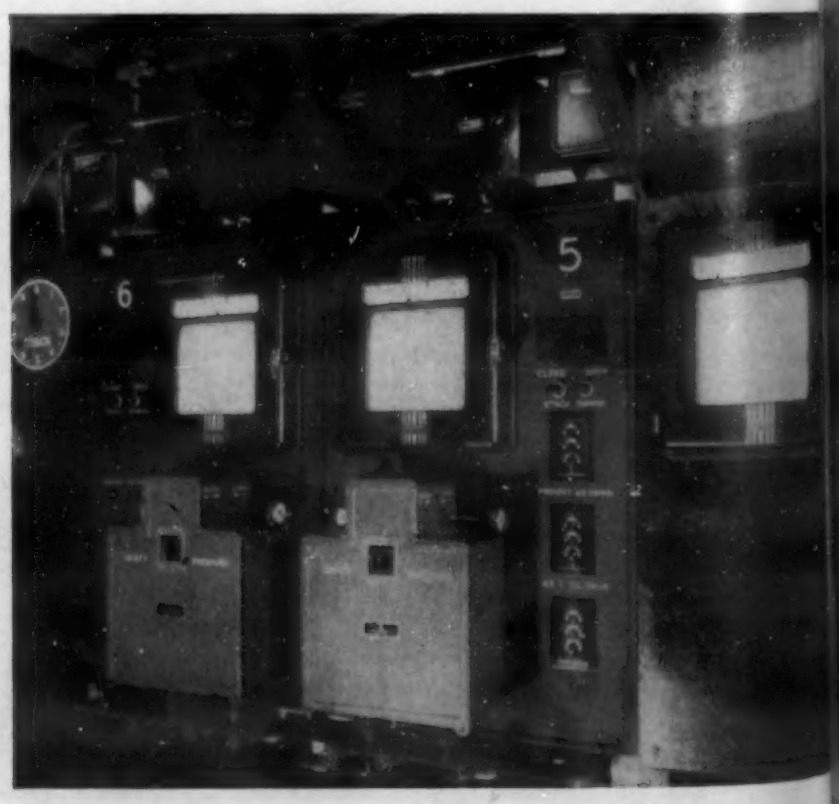
A typical control panel for a 150-ton, basic, open-hearth furnace, consists of measuring, indicating, recording, and controlling instruments. Located at one position, the first helper may see the measuring recorders and change the controls to obtain the condition that he may desire. The controls maintain the conditions which he sets until he makes subsequent changes. The furnace pressure controller and recorder are located at the left end of the panel. The flue temperature recorder and the temperature-difference controller for reversing are located in the next section. The combustion control instruments take up the remainder of the panel. They include a total B.t.u. input recorder, an oil flow recorder, a combustion air flow recorder, an atomizing steam flow recorder, a by-product gas flow recorder (not mounted), an oil flow controller, oil and steam pressure gages and various control knobs.

The method of combustion control provides for totalizing the combined fuel input to maintain a set B.t.u. input into the furnace. The amount of by-product gas to be used depends upon the available supply and is set separately by the first helper as well as the total B.t.u. input he desired. The oil flow is regulated automatically to hold the set B.t.u. input and if the gas supply falls off, due to an increased demand in other sections of the plant, the oil flow will increase automatically to make up the B.t.u. loss due to the decrease in volume of by-product gas.

Soaking pit control panel showing recording controllers connected to widely separated pits.



Another soaking pit control panel containing temperature recording controllers, draft pressure controllers and carbon dioxide recorders.



METALLURGICAL ENGINEERING news

Equipment • Finishes • Materials • Methods • Processes • Products
Alloys • Applications • Designs • People • Plants • Societies

The Production Front

by H. R. Clauser
Assistant Editor

War became a grim reality to the United States last month, and the metal industries, which are a most vital factor in its outcome, went on an all-out war footing. The steel industry, still harassed by scrap and pig iron shortages, hastened its expansion program by receiving higher priorities from the OPM. The fact was made known that our steel production is superior to the Axis powers 3 to 2.

Our supplies of tin, tungsten, chromium and manganese were all threatened by the war in the Pacific, and the government immediately took action to conserve and build up the stock piles of these vital metals. Copper came in for further inquiry as to available supply and consumption. At the same time, suggestions came from many groups to raise the price of copper as well as other vital metals as an incentive to increase production.

In order to give further aid to the small manufacturer and also speed-up our armament production, plans were announced to pool the available facilities of the small concerns and give them the necessary engineering assistance.

Iron and Steel

The entrance of this country into the war brought on renewed pressure to speed up the 10,000,000-ton steel expansion program. As a first step, the expansion projects were given still higher priority ratings, thus ranking with those for tanks and planes.

The most vital parts of the program at present, which need concentrated action, are an increase of pig iron facilities to balance the processing, fabricating and finishing processes, as well as to offset the imminent scrap shortage, and an increase in electric furnaces to provide the necessary special steels for armament purposes. Plans for 7,000,000 ingot tons of the 10,000,000 expansion program have been approved. This major part of the expansion has been designed for the specific needs of war production, including alloy bars, tool steel bars, cold finished bars, armor plate, special steel castings and steel plates.

A larger cut into the ever decreasing supply of steel for civilian production was predicted. The suspension of automobile production is definitive of the government's policy that points toward complete cutting off of non-essential steel requirements.

Even though steel production is not as high as we would like to have it, the American Iron & Steel Institute reported last month that the United States alone can out-produce the Axis countries 3 to 2. The combined steel output of the United States, the British Empire and Russia is over twice as great as that of the Axis total. Although our blast furnaces and rolling mills cannot fight in person up in the front lines, their strength in the fighting materials they produce is there and will eventually be the deciding factor.

More Scrap

The scrap shortage has become a perennial ill to the production of steel. Even though the 1941 consumption of scrap exceeded that of 1940 by around 11,500,000 gross tons, there still isn't nearly enough scrap to go around.

Last month an intensive drive for scrap was opened by the Bureau of Conservation of the OPM. The drive is aimed at two different groups, the industrial plants and the average citizen, and includes not only steel scrap but non-ferrous materials as well.

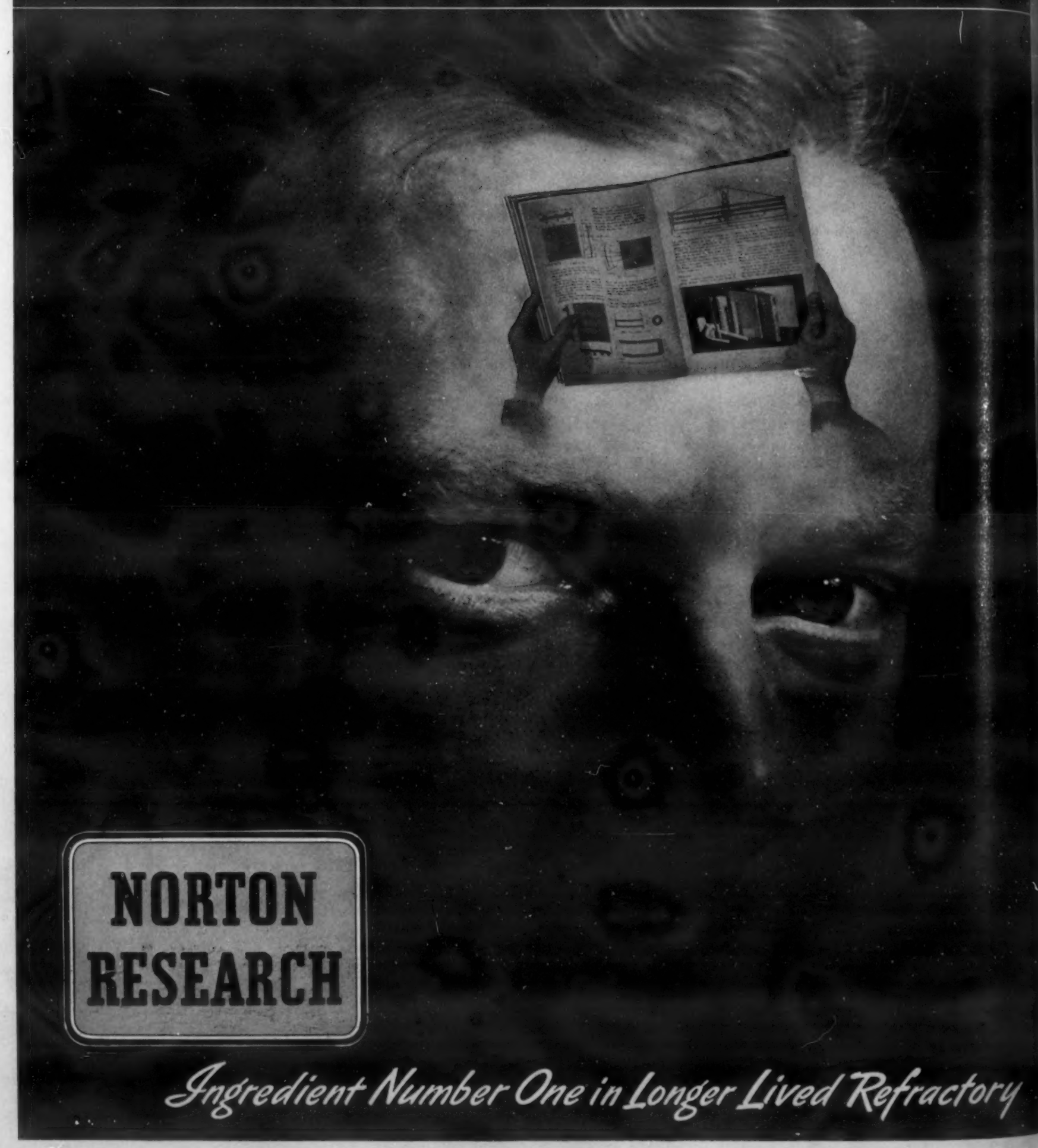
Every metal working plant has a considerable amount of waste, which has previously been allowed to accumulate without any definite, organized program of disposal. Besides the scrap from production processes, many plants have obsolete machinery, old pipe and tubing, ancient jigs, dies and patterns, etc., which could well be used to build up the rapidly diminishing scrap supply. As an example, it has been reported that in a single steel plant 134 carloads of such scrap materials were collected in two weeks.

Numerous metal working plants have long realized the virtues of saving and have set up separate, independent departments whose sole job is to take care of the waste products. It is at those plants which have not yet adopted such a program that this latest scrap drive is pointed.

Meetings extending over three weeks were held with OPA officials, scrap dealers, and all types of consumers in attendance. A product of those meetings was a revised iron and steel scrap schedule, which

(Continued on Page 102)

COLLECT OUR THOUGHTS



TO GET "JOB-PERFECT" REFRACTORIES

EVEN more variable than the grains, shapes and mixtures of Norton refractory products are the varying *jobs* for which they are engineered.

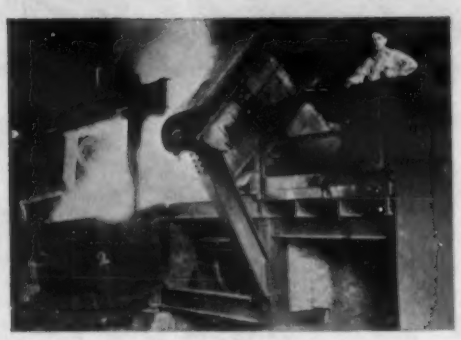
Norton technical literature reflects this wide experience in creating "job-perfect" refractories . . . to do your particular job better and longer.

Whatever complex of variables you may require — strength, correct porosity, resistance to acids, oxidation, abrasion, slagging, thermal shock — Norton engineers may, through past experience, immediately recognize the ideal compromise between your opposing needs.

Along with each Norton electric-furnace refractory product — silicon carbide, alumina or magnesia in the right shape or mixture — you collect the *thoughts* of Norton engineers, tested in field and laboratory, ready for immediate application in your plant.

Products

FIRING LINE NEWS



In Linings for Furnaces Melting Varied Metals Norton Cements Put Heat to Work for You

For pit furnace linings, crucible furnace linings, monolithic linings, patching, tamping and non-ferrous and non-lead melting, Norton CRYSTOLON (silicon carbide) cements are highly resistant and impermeable to slag. Like all CRYSTOLON refractory products, they are refractory without spalling, softening or appreciable expansion up to 1650°C, depending on the mix. Specially prepared to resist oxidizing conditions, they are unaffected by all acids except hydrofluoric.

ALUNDUM (Al_2O_3) Cements Cold-Shoulder Chemicals, Take the Punch of High Voltages

If you want a highly refractory product in melting pure metals, particularly those with high melting points — cements for resistor imbedding, burner block tamping, carbon and metal resistors, etc., — Norton ALUNDUM (electrically fused alumina) has the advantages of inertness to oxidation and most chemical conditions, plus excellent heat conductivity and high resistance to electricity at elevated temperatures. Like ALUNDUM Tubes, Cores and Muffles, refractory up to 1900°C, Norton ALUNDUM cements are refractory up to high temperatures (1600°C).

Also investigate Norton *Fused Magnesia* (magnesium oxide) products, including cements for lead cupels, crucible linings, and electric induction furnace linings for ferrous and non-ferrous melting. For instance, one form of Fused Magnesia mix is highly satisfactory, for insulating heating elements in enclosed units, and certain Fused Magnesia cements have excellent electrical properties for imbedding resistor wires.

Norton Questionnaire Provides Basis for Intelligent Consultation

Realizing that no one refractory is ideal, and that needs must be satisfied in the order of their importance, this questionnaire is designed to help you state your requirements.

Write us, with this questionnaire in mind! Norton engineers will then be able to provide you with longer-lived refractory products designed for *your* particular needs.

QUESTIONNAIRE

1. Outline the problem.
2. What are the conditions under which the refractory must operate?
   a. Is the furnace operation continuous or intermittent? What is the rate of heating?
   b. What will be maximum temp.?
   c. Will the refractory be in contact with slag? If so, is it acid or basic? Give chemical composition of slag if possible.
   d. Will the refractory be in contact with metal? If so, name metal(s).
   e. Will furnace be operated under oxidizing or reducing conditions?
   f. Must the refractory withstand abrasion?
   g. Must the refractory withstand load? If so, give the maximum load; distribution of load. Is refractory subjected to compressive or tensile stress?
   h. Is the refractory heated on more than one face?
3. If blocks and bricks prove unsuitable, can a monolithic lining be rammed in place? Can it be matured in place?
4. What types refractories used in the past? Your experience in regard to their suitability?
5. Source of heat: electricity; gas (city, producer, natural, etc.); oil (grade and kind); coal (kind; ash content, chemical analysis of ash if possible; % sulphur and fuel if possible; approximate fusion point of ash)?
6. Is installation to be insulated?
7. Are there electrical characteristics to be considered?
8. Is rapid heat transfer desirable?

Keeping Defense Furnaces From Going On Strike

Subjected to terrific temperatures, and severe heat shocks, the burner ports or blocks in large billet heating furnaces soon failed. Frequent downtime for replacing the burner blocks cut down the plant's production, which is 100% for defense.

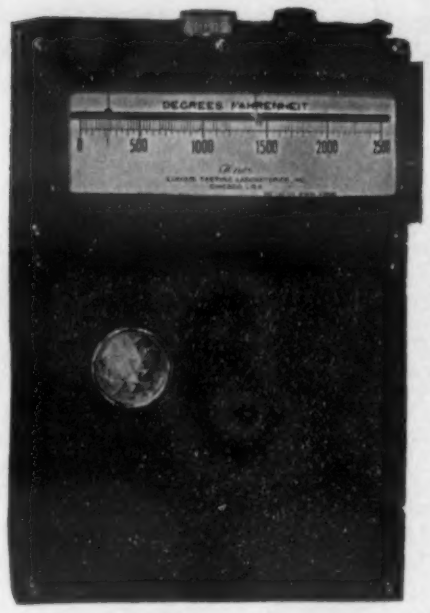
Norton engineers provided a specially designed ALUNDUM cement and worked out a special ramming technique. This combination gave results which are fulfilling the severe requirements.

Refractory Shapes and Cements of CRYSTOLON (silicon carbide), ALUNDUM (fused alumina), and fused Magnesia Grains

NORTON COMPANY, WORCESTER, MASS.

SHORT on TIME and METAL?

CONSERVE **BOTH** WITH THESE **DEPENDABLE INSTRUMENTS**



Alnor Pyrometer Controller

Designed to automatically control and maintain at a predetermined temperature the heat of any industrial furnace, melting pot, treating oven or other device heated by gas, oil or electricity. Eliminates rejects due to improperly controlled hardening and annealing temperatures and saves man-hours by automatic operation . . . Supplied in all standard temperature ranges from 0 - 600° to 0 - 3000° F.

Pyro-Lance Pyrometer

For Molten Brass, Bronze or Copper

The Alnor Pyro-Lance is a completely self-contained portable instrument which is practically indispensable for the production of sound non-ferrous castings. Ruggedly designed for direct immersion in molten brass, copper or bronze, the Pyro-Lance can help every foundry-man to cut scrap losses and reduce fuel consumption.

Alnor Wall Pyrometer

A low cost instrument which has proved itself for accurate, sensitive temperature measurement in heavy duty service . . . Ideal for small heat treating and annealing furnaces, soft metal pots, die casting machines and galvanizing vats.

Alnor Pyrocon

An improved type surface pyrometer that will give accurate temperature readings of any flat, curved, stationary or revolving surface in a few seconds . . . Ideally adapted to checking surface temperature of molds and for determining pre-heat temperatures in welding operations. Ten interchangeable thermocouples assure maximum, all-purpose utility. Available in standard ranges from 0 - 300° to 0 - 1200° F.

A complete Alnor Catalog of Time and Material saving instruments will be sent on request. Write for your copy now!

Illinois Testing Laboratories Inc.

Pond Guests Know!

425 N. LaSalle St., Chicago, Illinois

segregates the various types and grades of scrap according to uses, and establishes maximum prices for each type of consumer. The chief purposes of the revision are to encourage increased collection of scrap, and direct the various kinds of scrap to plants for the most advantageous use.

Non-Ferrous Metals

Japan's vicious attack in the Pacific last month was largely precipitated by the lure of those vital metals—tin, tungsten, chromium and manganese—which are literally as precious as gold to the modern war machine. Because of their indispensability, the United States has taken steps in an attempt to assure an adequate flow of these metals for our military needs.

Tin is probably the most important of our Far Eastern imports, and is the hardest to replace. Last year we obtained about 92 per cent of our tin from the Far East. "The Daily Metal Trade" estimated that the total stocks of tin in the United States would be sufficient for 13 months at normal demand levels. A new smelter is under construction in Texas, but when completed, it will not be able to supply more than a third of our normal requirement, which is between 90,000 and 100,000 long tons per year.

Consequently, on December 18th the Federal Government took charge of all tin supplies coming into the country. By careful conservation and rationing, it is expected that the supply can be made to last through the emergency period. OPM's suspension of the lead and tin foil order, which had originally banned the use of this type of foil for packaging gum, cigarettes, etc., will probably again have to be revised.

The supplies of manganese, chromite and tungsten are endangered. About a third of our chromium supply comes from the Pacific area; tungsten comes to us by way of the Burma Road. Because of the threat to the tungsten supply, an order was issued by the Government, providing that only 25 per cent of all high speed steel orders accepted in any one quarter may be of the tungsten type. Previously, 50 per cent of the total was allowed. Plans for rapid expansion of domestic production of manganese from low-grade ores are under way. Increased manganese imports from Brazil, Cuba and South Africa should help alleviate the situation.

Copper production and supply were again questioned last month by some members of Congress and elsewhere. As a result, public hearings on the matter were ordered by SPAB. The contention by many that copper is not short is partially true. The United States will have available about 1,800,000 tons of copper in 1942. Defense needs plus lend-lease will take 1,200,000 tons. Another 400,000 tons will be used to meet essential civilian demands. This leaves 200,000 tons for ordinary consumer production. To the advocates of the "both butter and guns" program, 1,170,000 tons more is neded for civilian goods, and that is where the shortage lies.

Production Pools

The engineering advisory committee of the OPM's Division of Contract Distribution met the middle of last month to determine ways of speeding production and of

(Continued on page 104)

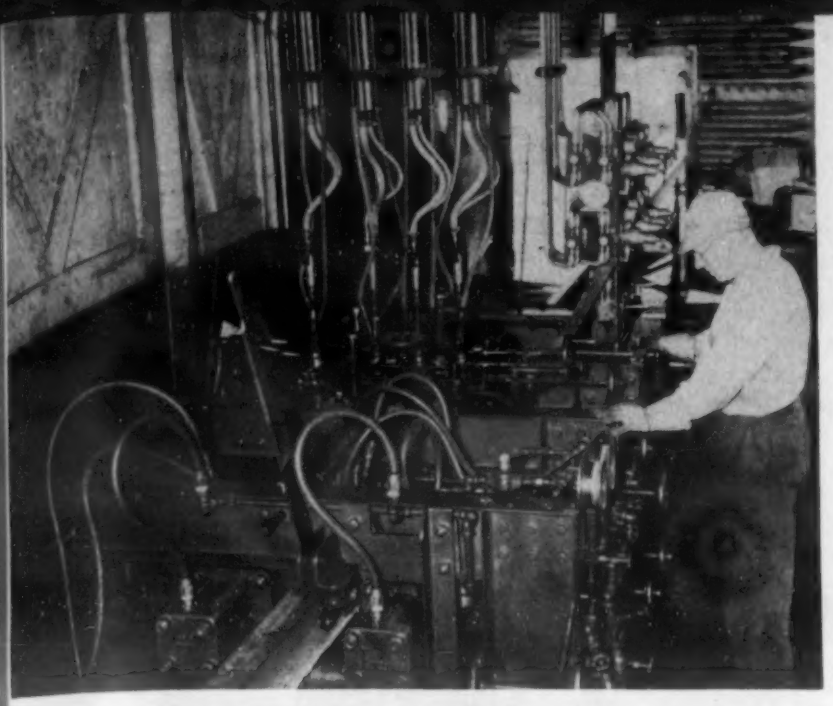


Fig. 1. The pressure butt welding machine in operation, joining together the ends of two rails.

Fig. 2. A pressure butt welded rail before trimming.

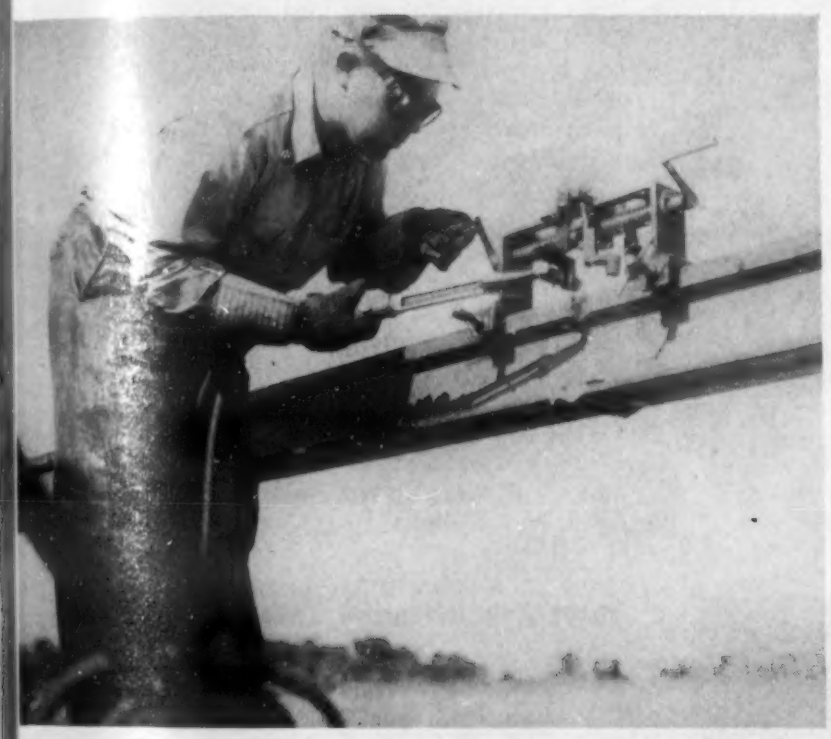


Fig. 3. Trimming upset weld metal with an oxyacetylene cutting blowpipe.

Continuous Welded Rails

In recent years much study and experimentation has been devoted to the elimination of the joints in railroad track. Three distinct welding procedures have been developed and used successfully — the thermit process, electric flash butt welding, and oxyacetylene pressure welding.

Here is presented a sequence of pictures illustrating the oxyacetylene pressure welding process. By this method the properly prepared ends of two rails are pressed together and aligned in a machine, where a series of oxyacetylene flames are applied completely around the rail ends. When the metal reaches the plastic state, the applied pressure of around 2,500 lbs. per sq. in. forces the ends together and the joining is completed. The excess metal at the weld, which has become upset during the welding process, is then removed and the weld zone is reheated to above the critical temperature in a normalizing operation, which refines the grain.

All the operations are performed on railroad cars, and the welded rail in lengths up to 1,560 ft. are transported to the site of installation on flat cars.

Fig. 4. The normalizing unit in operation.

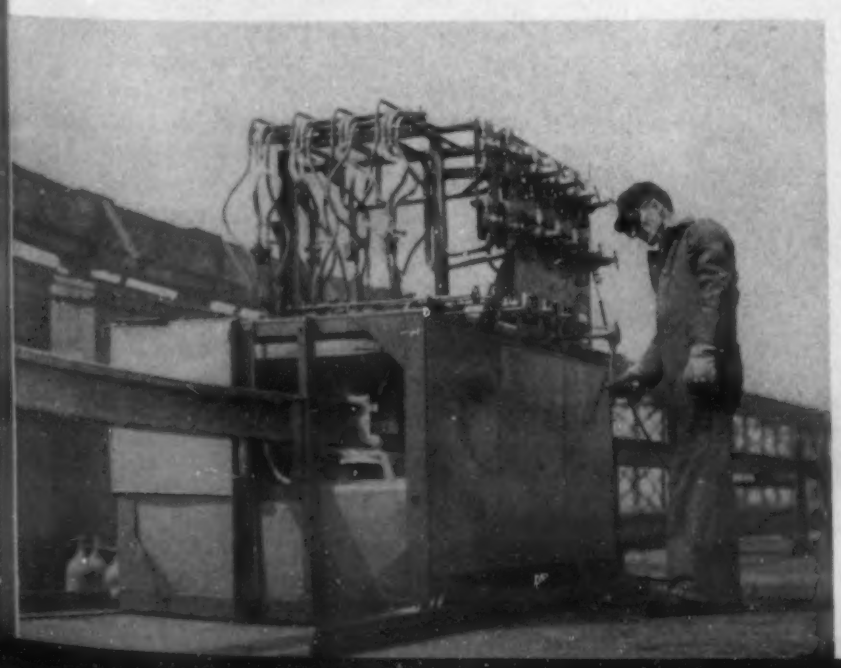


Fig. 5. The finishing process. Grinding the welds to a smooth-riding surface.

using industries' facilities to the fullest. They reported that subcontracting and pooling of resources of American industry was necessary for any material expansion in armaments production.

Out of this report has grown a plan to organize local defense production associations through which small manufacturers can pool their resources and jointly produce war material as well as consumer goods. The washing machine and ironer manufacturers have already employed this scheme to advantage.

For the successful operation of this plan it is quite necessary to have capable engineering control and supervision. The OPM realizes this, and has promised the best engineering and organizing talent available for the task of conversion.

New Molding Process

Walco Plastics, East Orange, N. J., has announced a new process of plastic molding whereby sheets of thermoplastic material, such as cellulose acetate, are molded with a single operation into such intricate shapes as radio cabinets, fluorescent lighting fixtures, seamless, rigid, transparent acetate boxes, and a wide variety of articles having compound curves and angles.

In the past, these articles have been produced from plastics by the well-established injection and compression molding methods, which utilize molding powders and require relatively costly dies. The incorporation of a new mold construction, combined with a pretreating process before molding the sheet, makes possible a low die cost and, therefore, make small as well as large production runs economically possible.

The Walco process of molding thermoplastic sheets opens interesting design possibilities because it takes sheet plastics out of the ordinary fabricating realm in which only simple curves are obtained. As an illustration, cellulose acetate has a large market in the packaging and display field, but its use has been limited to some extent by the fact that it could not be readily formed as an integral unit article with compound curves and angles. As a result, it is generally used in conjunction with paper, cardboard, metal, or another plastic, which serves to hold it in shape.

With the Walco process, a single operation between male and female dies transforms a flat sheet of acetate, or any thermoplastic sheet, into a finished article with as many or as few curves, corners, or angles as are desired. Ridges can be molded with greatly increased strength and dimensional stability. Unlike many compression or injection molded or cast phenolic articles, the sheet molded product will not usually require a buffing or polishing operation to smooth down rough edges or die seams.

Another interesting possibility is presented in the sheet molding of very thin-walled articles. Injection and compression molding is seldom practical for walls of less than 0.030 in. thick. This new process molds sheets from 0.005 in. up to more than 0.500 in. thick. Thus, while the thermoplastic sheets, before molding, cost more per lb. than some of the molding powders, a compensation can often be effected because of less expensive dies and by supplying considerably thinner walls than might be practical with compression or injection molding, or casting of liquid plastics.

Of considerable interest to engineers is the fact that products molded by the Walco process show scarcely any variation in thickness throughout the finished article. A radio cabinet molded to a depth of 6 in. is very little thinner at the point of its extreme depth of mold, in this case its front panels, than the rear parts of the top and bottom sections. This uniformity is achieved during the molding process when, under the heat and pressure of the die, an actual flow of material within the sheet takes place.

Grinder with Dust Collector

A new unit, for tool and light snagging grinding with self-contained dust collector, has been introduced to the market by *Hammond Machinery Builders, Inc.,* Kalamazoo, Mich.

Design of these new machines features the completely self-contained dust collector. The dust collector unit is mounted inside the base of the grinder. The only parts outside are the fan motor, connecting pipes from wheel guards to dust collector, and air exhaust vent-guard.

The filters of fiber glass, 3 in number, provide for efficient air cleaning. Because of the shape of the air ducts within the base, the heavier grinding particles are carried down to a compartment in the bottom of the filter housing; only the lighter particles and air go through the filters.

It is claimed that with this system filter replacements are not needed as frequently as those employed in dust collectors in which all the grinding particles are collected by the filters.

Blast Cleaning Bombs

The illustration shows an automatic airless "Rotablast" cleaning machine, manufactured by the Pangborn Corp., Hagerstown, Md., giving 500 lb. bombs their final cleaning operation to remove all scale and dirt from their exterior surfaces. The bombs pictured have just been received at the loading end of the machine after their inside surfaces have received cleaning treatment at other cleaning stations.

Three New Industrial Tubes

Three new industrial tubes—a thyratron, a kenotron, and a phototube sensitive to blue—have been announced by the *General Electric Co.,* Schenectady, N. Y.

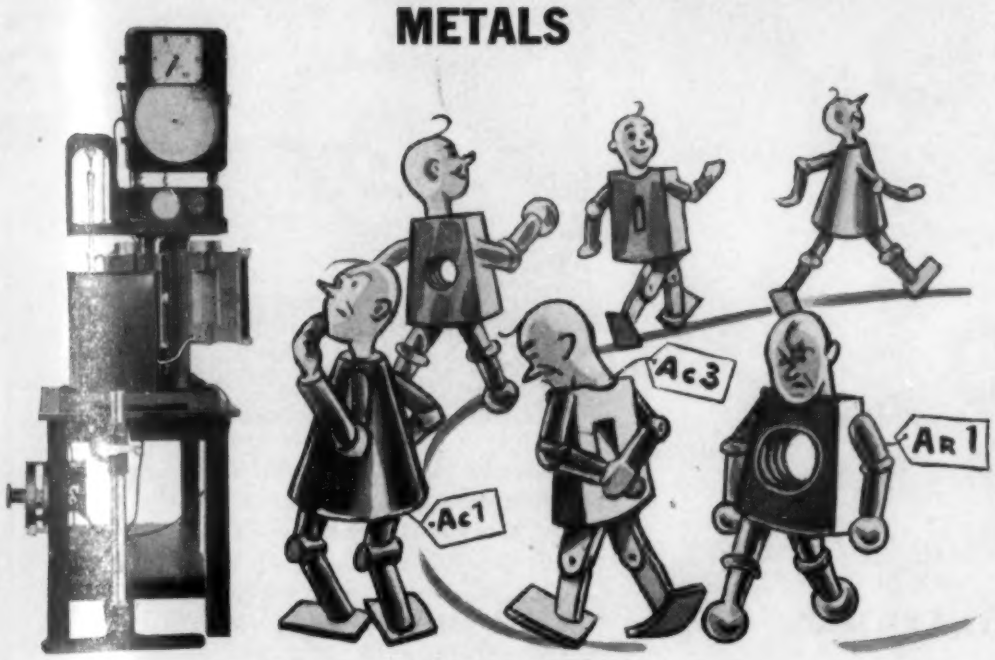
The newly designed thyratron is an all-metal negative-grid tube for general-purpose industrial applications. Since it has a shield grid, it is said to be especially suitable for control circuits where the available grid power is very small, and where it is desirable to actuate the grid from a high-impedance source.

The kenotron is a half rectifier, rated 30,000 volts peak inverse, 500 milliamps. peak, 100 milliamps. average. It is reported that its thoriated tungsten filament makes possible a higher rating for size than does a pure tungsten filament. This tube is designed to meet high-voltage, low current requirements. It is especially suitable for use with smoke-precipitation and air-cleaning devices.

The phototube is especially designed for a high response in the blue region of the spectrum, and is said to have 30 times the quantum efficiency of red-sensitive tubes. Sensitivity is 45 microamperes per lumen at an anode voltage of 90.

(Continued on Page 106)

QUICK COMFORT FOR MISUNDERSTOOD METALS



From Sub-Zero to 2500°F., Bristol's Dilatometer Gives You Clear Picture of Criticals and Reversals

The Rockwell Bristol Dilatometer gives you a dependable indication and ink record of time-dilatation and temperature-dilatation changes *simultaneously* during heating and cooling cycles of ferrous and non-ferrous metals, ceramics and many other rigid materials.

Some companies report that the first test made with this Dilatometer revealed flaws that fully repaid the cost of the instrument. You may get similar *immediate* returns on your Dilatometer investment.

A Dilatation is plotted against both time and temperature on one conventional chart. No poring over photographs, no painstaking calibration. Sharp, clear dilatometric reversals give you exact understanding of metals classified by their actual heat-treating criticals.

Simpler to operate and superior in construction to foreign Dilatometers now impossible to obtain, this 100% American-made instrument needs no expert to run it . . . is highly practical for both production and laboratory use. *Write for Bulletin 546,* for complete details, addressing 114 Bristol Road, Waterbury, Connecticut.

TRADE MARK BRISTOL'S REG. U.S. PAT. OFFICE

GAS TOO LEAN? TOO TARRY?

Bristol's Pyromaster Controls Fuel In Producer Gas Machines

Absolutely uniform temperatures, and more economical output at *lower* temperatures, are made possible by placing Bristol's Pyromaster in charge of fuel bed depth in your producer gas machines. And when Air Feed & Saturation controls are added, even better results are obtainable —volatile contents higher, tarring troubles reduced.

Many plants have found that a Bristol Pyromaster pays its own way as a coal feed regulator when over-heated gases are too thin, over-cool gases too tarry. But why not get facts on the *complete* installation, controlling air feed and saturation as well as fuel? Write for detailed data on Producer Gas Machine Control.

TRADE MARK BRISTOL'S REG. U.S. PAT. OFFICE

... Gives YOU the Most from Heat

THE BRISTOL COMPANY

WATERBURY, CONNECTICUT

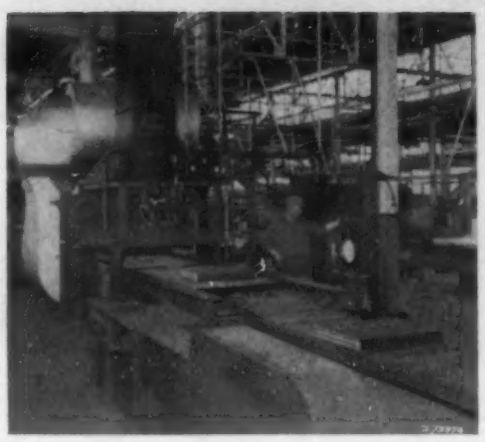
THE BRISTOL CO. OF CANADA, LTD.
Toronto, Ontario
BRISTOL'S INSTRUMENT CO., LTD.
London, N.W. 10, England

AUTOMATIC CONTROLLING AND RECORDING INSTRUMENTS

Soldering Automatically

The complicated soldering job on automobile radiators is now being done automatically instead of by hand at the *Fedders Manufacturing Co.*, Owasso, Mich.

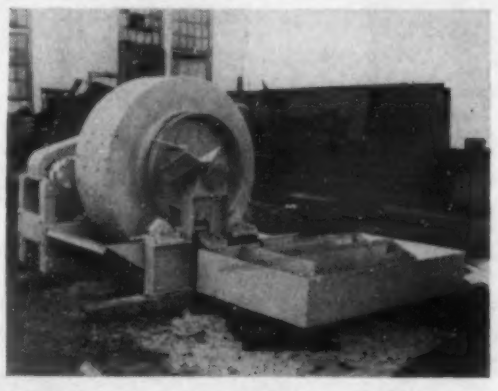
The assembly of copper tubes, fins and solder are placed in position on an electrically operated conveyor, a product of Mechanical Handling Systems, Detroit. First the assembly passes through a flux spray and then on into an oven. The oven-heating cycle is operated in synchronism with the conveyor movement, using electrical controls developed by the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



After a fixed time in the oven, long enough to bring the solder to a flow point, the conveyor starts again and moves the radiator core into a press, where it is held flat and square while an air blast is also controlled automatically in time with the conveyor and press movement. After the ore is sufficiently cooled, the press opens and places the core again on the conveyor, which delivers the finished core at the discharge end.

Metal Reclaiming Mill

Dreisbach Engineering Corp., Yonkers, N. Y., has developed a small all-steel metal reclaiming mill, as shown in the illustration, especially designed and priced for the small non-ferrous foundry having an accumulation of 2000-20,000 lbs. per month of skimmings, cinders, core-butts and sweepings, which run 10-60% metal.



This mill operates on the same principle of milling and specific gravity separation, with closed circuit, recirculating water system, as is used in the larger size mills in production service for many years. The rolls, made of wear resisting steel, grind the material above water level and are easily accessible for replacement. The mill has a 3 h.p. "V" belt direct drive to center roll shaft, with gear and roller chain reduction to drum. All the parts are covered with heavy metal guards, and have extra large well lubricated bearings. The complete unit is mounted on a rigid steel frame, assembled complete, to be placed and bolted to floor. This mill recovers all metal clean and free from oxides, ready for remelting.

Dust Collector

Where it is desirable to get rid of the dust from relatively small grinding, buffing or polishing operations, *Aget-Detroit Mfg. Co.*, Detroit, has developed a compact, self-contained unit dust collector.

The unit is designed to arrest dust at its source before it can do damage to equipment or spoil precision work. It is said to be easily installed, economical, efficient in operation, and easily moved about.

● A recent proposal, reported by *Chas. Hardy, Inc.*, New York, for making "clad" metals (for example, steel coated with copper) involves subjecting the steel to an oxyacetylene flame carrying by entrainment a flux like methyl borate. While the steel is under the influence of the flame and the entrained flux, finely divided copper is dropped into the heated zone, where it melts and flows into a continuous sheet bonded to the steel base.

NOTICE

For production furnaces—either electric or fuel fired—for *any* heat treating process—for handling *any* product or for *any* production, consult The Electric Furnace Co., Salem, Ohio . . . Our large and experienced engineering staff and ample manufacturing facilities enable us to make reasonably prompt deliveries.

THE ELECTRIC FURNACE CO.
SALEM, OHIO
U. S. A.

★

Bending Press Clutch Mechanism

A new electrically-operated clutch and brake mechanism has recently been developed for steelweld bending presses by *Steelweld Machinery Div., Cleveland Crane & Engineering Co.,* Wickliffe, Ohio.

This mechanism is said to reduce the fatigue of the press operator to a large extent by eliminating the usual physical effort required to engage the clutch manually. It is no longer necessary to hold the foot on the treadle to keep the clutch engaged, although such an arrangement can be provided if desired.

The mechanism is set in operation by depressing the foot treadle, which actuates the switch and brings the torque motor into play. Only a slight pressure of the foot is required to operate the treadle, since it merely closes the small switch. The gear segment is thereby brought to either one of the extreme positions, depending upon whether the clutch or brake is being engaged.

A safety toggle makes operation of the mechanism positive and practically foolproof. Because of this toggle, there is no danger of clutch or brake being engaged or disengaged unintentionally.

● A new series of tools in large turning and facing styles for heavy machining has been developed by *McKenna Metals Co.,* Latrobe, Pa. The position of the tip in the shank permits a greater thickness of steel under the cutting point of the tip, permits the top surface or chip breaker to be ground without the necessity of grinding away steel, and during the life of the tool the height of the cutting point is retained rather than lowered each time the tool is ground.

Torsion Machine for Wire

A new torsion machine for wire and wire products has been developed by the *Riehle Testing Machine Div.,* American Machine & Metals, Inc., East Moline, Ill.

The machine has been designed to perform tests in accordance with the specifications set forth by the American Society for Testing Materials. The gripping heads are adjustable for convenient positioning of the specimen, and a three-figure revolution counter is provided for determining the number of turns required for failure.

Checking Pickling Concentrations

An instrument, known as the solu-bridge, has been developed by *Industrial Instruments, Inc.,* Jersey City, N. J., for checking pickling bath concentrations and similar solutions.

The instrument is a rugged, simplified, shot-type, Wheatstone bridge, which utilizes the "magic eye" principle for indicating the condition of balance, and serves to measure the electrical conductivity of the solution in the desired terms.

The readings are obtained directly by turning a knob until the "magic eye" indicates balance. In the case of pickling solutions, the readings are obtained in terms of sulphuric acid concentration.

SYMBOLS of DEFENSE

This "up and at 'em" tiger is the symbol of the 24th Pursuit Squadron, one of the powerful aviation units now preparing to defend American rights. Symbol of industrial strength which steels America's fighting arms is Lebanon's famed "Circle Ⓛ".

DATA TO HELP AMERICAN INDUSTRY

Fight Corrosion

CIRCLE L

Physical Characteristics of Circle Ⓛ 30

A 24% Chromium, 11% Nickel Type Stainless Alloy — Carbon Maximum .20

Resists sulphite liquors. Widely used for digester fittings, valves, pumps, strainers, etc. Write for data sheet listing all corrosive materials and chemical reagents resisted by Circle Ⓛ 30.

Tensile Strength	75,000 to 90,000	Magnetic Properties	Non-magnetic
Yield Point	35,000 to 45,000	Thermal Conductivity (C.G.S.)	0.030
Elongation in 2"	25.0 to 40.0%	Specific Gravity	7.85
Reduction of Area	25.0 to 40.0%	Specific Heat—Room Temperature	0.12
Brinell Hardness	145 to 175	Mean Coefficient of Thermal Expansion 32° F.—212° F.	0.0000085
Impact Value (Izod)	40 to 80 ft. lbs.		

Lebanon metallurgists are studying future applications for stainless steel castings . . . and are ready to discuss significant developments with forward looking organizations.

LEBANON STEEL FOUNDRY • LEBANON, PENNA.

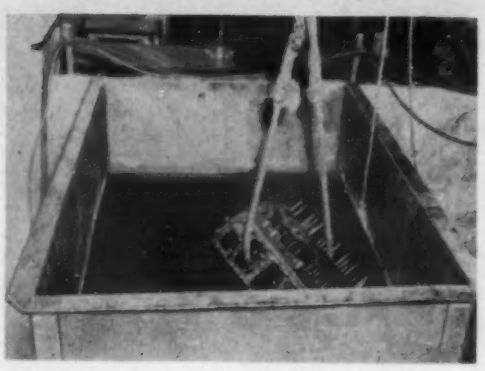
ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON *Stainless and Special Alloy* STEEL CASTINGS

New Cleaning Solvent

The Curran Corp., Malden, Mass., has announced the development of a new mineral grease and dirt digestive solvent. It is stated that the newly developed digestive solvent tank is a superior substitute for trichlorethylene vapor phase metal cleaning tanks, particularly in heavy duty automotive or similar applications where there is much insoluble dirt or smut to be removed.

The new cleaning method is carried out by cold immersion of greasy or dirty parts. The new solvent, it is said, not only takes the cling out of hard mineral dirt and grease accretion, but emulsifies them as well, so that they may be instantly and completely rinsed away by sluicing with a water hose.



Portable Arc D-C Welder

For all-purpose welding in industrial plants, shipbuilding, and for general maintenance work, a new portable arc welder is announced by *Westinghouse Electric & Mfg. Co.*, East Pittsburgh, Pa. The ratings are 200, 300 or 400 amps. for 220, 440 and 550 volt a.c. circuits; 2 and 3 phase, 25, 50, and 60 cycles.

Current adjustment is obtained by a ball crank making it possible to preset the desired current before welding. Steady current regardless of arc length is provided by arc control, which can be adjusted to suit the welding job.

In operating, a magnetic shunt is placed in the armature reaction flux path. Output current of the welding generator is adjusted by ball crank control of the position of a laminated iron leakage block. This block serves as a magnetic shunt for the reaction flux of the machine, and its position with respect to the main flux path determines the welding current. By this principle, no field rheostat exciter or external reactor is required.

● It has been proposed to produce metal powders, according to *Charles Hardy, Inc.*, New York, by co-precipitating compounds of a metal such as copper, which is readily reducible with compounds of other metals that are much less reducible. The resulting mixed precipitate is subjected to a disassociation or reduction treatment to convert the first compound to finely divided metal distributed through the unreduced compound of the other metal. The unreduced compound is then removed, for example, by leaching.

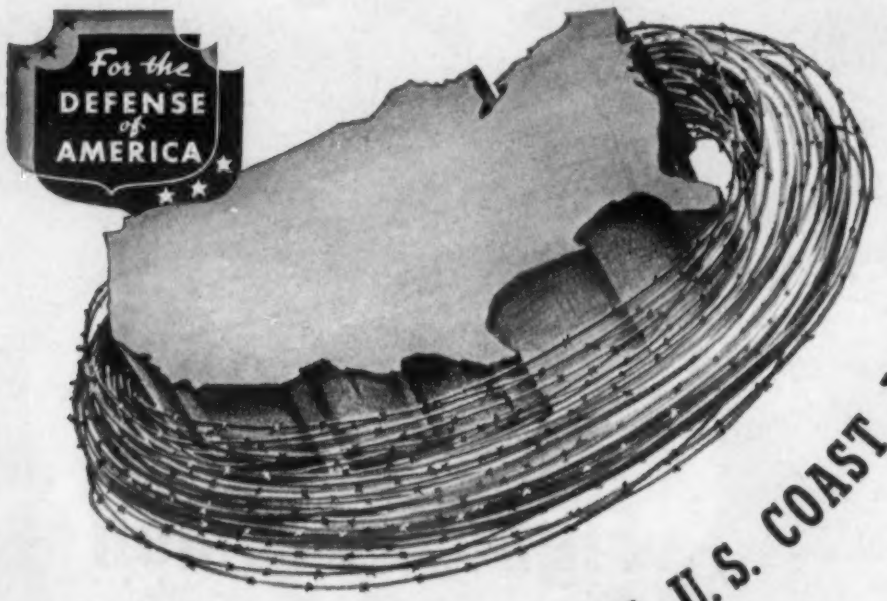
News of Metallurgical Engineers

K. E. Dinius has been appointed chief engineer of South works of Carnegie-Illinois Steel Corp. He was formerly electrical engineer in the engineering department of the same company. . . . . *T. I. Phillips*, formerly assistant to the president of Westinghouse Electric & Mfg. Co., was recently elected to a vice presidency in the company.

The first appointment to a full professorship in powder metallurgy at any institution in the country was given to *Gregory Jamieson Comstock* at Stevens Institute of Technology. . . . . *R. W. Straus* has been elected president of the American Smelting & Refining Co.

Edward M. Murphy, formerly assistant to superintendent of Newburgh Wire Works, is now division metallurgist of American Steel & Wire Co. . . . *Henry B. Duffus* has been appointed mechanical safety engineer at Westinghouse Electric & Mfg. Co.

● Engineers of the *Tuff Hard Corp.*, Detroit, have reported the development of a new heat treating process for various types of cutting tools. The process is said to be especially applicable to molybdenum high speed steels.



YOU COULD CIRCLE THE U.S. COAST LINE 250 TIMES

• RODINE ***saved steel enough to make more than a million miles of barbed wire***

You could barricade the U. S. coast, circle the Equator more than 50 times, with barbed wire that could have been made from the steel saved by *Rodine* last year . . . steel which might have been lost by acid attack in pickling. *Rodine*, in the world's pickling baths, saves labor, acid, reduces brittleness, blistering, corrosion, eliminates formation and escape of acid fumes. For 20 years, ACP products have served by *saving* and *protecting* steel. Adequate stocks are available. Write for Bulletin No. 13.

CUPRODINE is the ACP granular material used in solution for producing a fine bright copper coating on steel by a simple immersion process. Ask for Bulletin No. 13-9.

RODINE Saves STEEL

AMERICAN CHEMICAL PAINT CO.

MAIN OFFICE AND WORKS
AMBLER . . . PENNA.

CHEMICALS ACP PROCESSES

DETROIT, MICH., 6339 Palmer Ave., E.
CANADIAN BRANCH
WALKERVILLE . . . ONT.

Plants and Slants

E. I. duPont de Nemours & Co., Inc., has opened its new cyanide products service laboratory at the Niagara Falls, N. Y., plant of the R. & H. Chemicals Department.

The Lockheed Aircraft Corp. and the *Vega Airplane Co.* have announced the start of construction on what is believed will be the biggest flight service hanger in the United States.

Some 800 men from the Philadelphia area are learning how to produce vital marine equipment at the "industrial college" in the *Westinghouse* South Philadelphia works.

The Atha Works of the *Crucible Steel Co. of America* has a vast program of plant expansion under way. Among other things, the electric furnace capacity is being nearly trebled.

The Armour Research Foundation at Illinois Inst. of Technology is constructing a fully equipped building for metallurgical research. It will provide the middle west with the largest and most complete facilities for the conduct of developmental and industrial research in this field.

The Baldwin-Southwark Div. of Baldwin Locomotive Works has received an order from the Russian government, through Amtorg Trading Corp., for 10 large extrusion presses and auxiliary equipment.

Construction work for the new plant of the *Northwest Magnesite Co.*, Pittsburgh, is actively under way at Cape May Point, N. J. Synthetic magnesite by the Chesny process for refractory purposes will be manufactured here.

The Foote Mineral Co. has recently purchased a new grinding and milling plant at Exton, Pa.

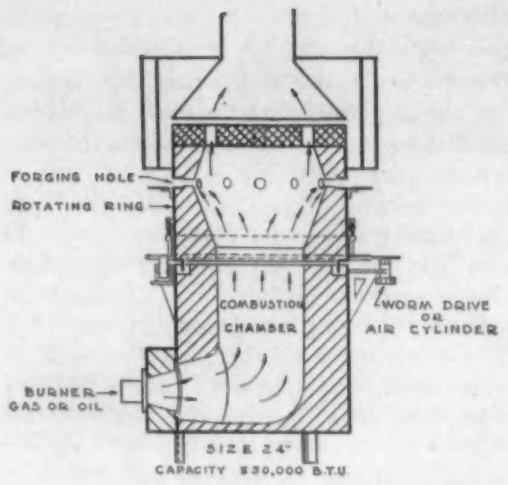
The old Savannah Avenue plant in Canton, Ohio, has been revitalized by *Timken Roller Bearing Co.* for the purpose of manufacturing 37 mm. shot.

The Haverhill Aircraft Die Casting Corp. Los Angeles, recently announced that the Harvill die casting machines, techniques and production methods will be offered to other companies in order to speed up production of magnesium-, aluminum- and copper-base alloy die castings.

● *The Diamond Tool Co.*, Chicago, announces a new design feature which is to be incorporated in all its diamond nibs in the future. This new feature consists of 2 internal locking keys that are integrally cast on the slug-holding nib by forcing the molten metal into 2 internal key seats milled in the nib head. It is claimed that diamonds set in this manner never shift, turn or loosen in operation, making possible micrometer adjustment of each pass.

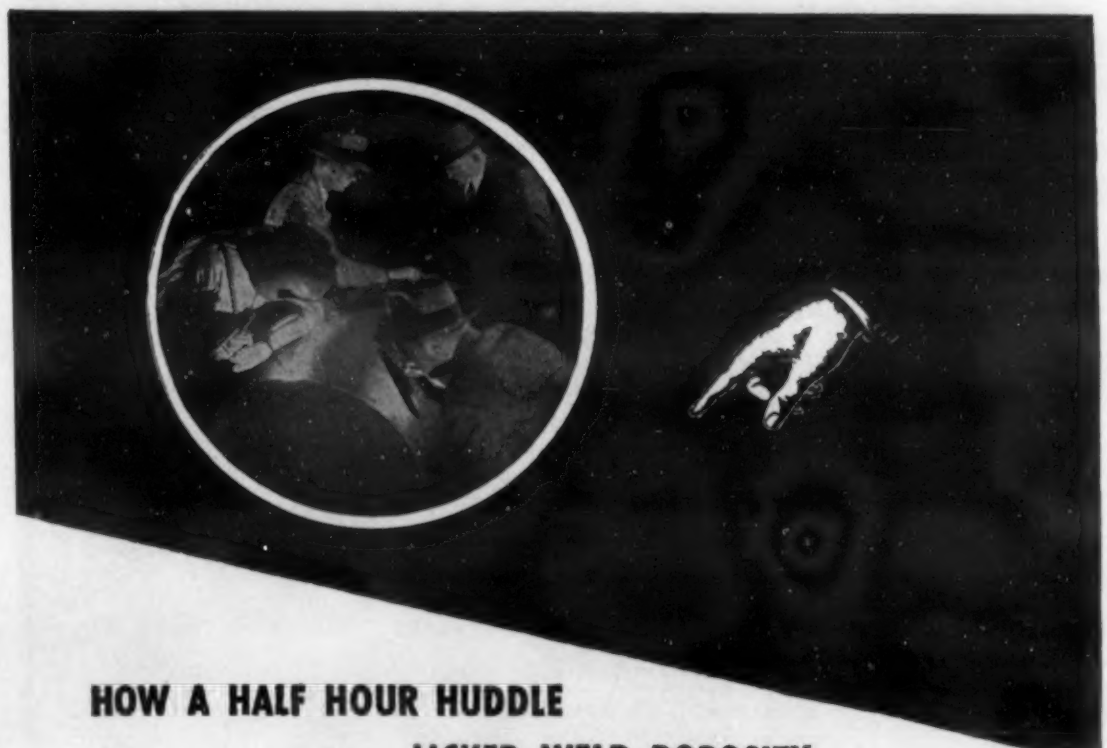
Rotary Forge Furnace

A new rotary forge furnace has been developed in which the burned gases are so handled and so distributed that extreme uniformity of heat is possible, assuring fast uniform production, according to *Rhode Island Tool Co.*, Providence, R. I.



The atmosphere in the combustion chamber can be controlled to prevent the formation of scale, and there is no fly ash to cause excessive wear on forging tools. The furnace, available in 24 in. and 36 in. sizes, is said to have a very fast reducing heat, permitting a great capacity for its size. The burner may be fired by bunker oil, Nos. 2 or 3 fuel oil, and natural or artificial gas.

The forge ring is indexed by depressing a simple foot control, leaving the operator's hands free for handling stock and controlling the forging machine. No fireman is required, and the operator suffers a minimum of heat radiation.



HOW A HALF HOUR HUDDLE LICKED WELD POROSITY

IN the present crisis the immediate correction of production welding troubles is imperative. That is where your nearest Murex representative can be of help.

In one shop, for instance, difficulty was being experienced with weld porosity in oil storage tanks. Our engineer quickly traced the cause to the use of excessive welding current, which was resulting in trapping slag from the iron in the welds. A change in procedure, calling for lower currents and involving downhill welding, eliminated the trouble by making it necessary to advance the electrode more rapidly. Thus, heat input was reduced and the building up of high beads prevented.

When you are stumped by a welding problem, you will find invaluable our Murex engineers' knowledge of welding procedure, weld design and shop practices.

Specialists in welding for nearly 40 years. Manufacturers of Murex Electrodes for arc welding and of Thermit for repair and fabrication of heavy parts.

METAL & THERMIT CORPORATION 120 BROADWAY, NEW YORK, N.Y.

ALBANY • CHICAGO • PITTSBURGH • SO. SAN FRANCISCO • TORONTO

MUREX
ARC WELDING ELECTRODES

"Self-Made" Carbide Tools

To speed its production of war items such as air craft engines and parts, *Buick Motor Division,* Flint, Mich., has eliminated virtually all delays incident to obtaining special tungsten carbide tools from tool manufacturers by producing such cutting tools—at a saving in cost—in its own plant in Flint.

Carbide tools are produced at Buick by brazing standardized sizes of carbide tips to shanks of S.A.E. 1340 steel. The procedure is as follows: Shanks are ground to size on all four sides from hot rolled stock (containing no strategic tungsten) on water type surface grinders. From here they go to the milling department where the recess for the tip is milled out, and the shank is stamped, ready for brazing the tip in place. The tip itself is polished on bottom and contact sides with a diamond wheel.

For brazing, Buick has also developed an unusual setup which permits the use of City gas instead of requiring the usual oxyacetylene torches, or electric furnaces, etc. The brazing equipment consists of a fixture having a flat top, on the back of which have been attached 6 fishtail gas tips —arranged in such a position that the tool held in a vise can be slid into position between 3 flames on each side. The vise itself rests on the flat surface of the fixture. The operator thus has both hands free with which to handle the tip and brazing material to assure getting a good braze. While one tool is heating, the operator prepares another tool for the vise.

City artificial gas is used to produce the flame by mixing it with air through a venturi tube at each one of the jets. Adjustment of the tops regulates the heat.

Welding Torch for Airplane Construction

To specifically serve aviation, the *Alexander Milburn Co.,* Baltimore, Md., announces the release of their new type MM Welding Torch. According to the designers, it is lightweight, easy to operate, has accurately controlled flame that is adaptable for intricate work, yet hot enough to permit its use as a heating torch.

The torch is designed to give best results on thicknesses of ⅛ in. and less up to ½ in. It is particularly useful with stainless steel and similar alloys requiring exact heat and flame control. Because of its balanced design, it is said to be extremely useful in working around the awkward shapes often confronted in airplane construction.

● *The Dow Chemical Co.* recently received the 1941 award for Chemical Engineering Achievement for its pioneering research in recovery of metallic magnesium from sea water. The award is presented biennially by the magazine "Chemical & Metallurgical Engineering." The achievement that merited the award was the development of a process for recovering magnesium metal from sea water in a plant recently completed at Freeport, Texas.

Seamless Tubing Machine for Shells

A machine designed originally in 1933 to produce seamless steel tubing for the *Timken Roller Bearing Co.,* Canton, Ohio, is now turning out shell forgings.

The machine, an Assel cross-roll and elongator mill, has been revamped by the Salem Engineering Co., so that it can turn out 75, 90, 105 and 155 mm. and 5 in. shell blank forgings. Although originally set up for an estimated production of 280 75 mm. shell forgings an hr., numerous hourly runs of over 300 are reported.

Engine-Driven Welders

The Harnischfeger Corp., Milwaukee, has just introduced two new gas-driven welder units with capacities of 15-200 amps. and 30-260 amps.

According to the manufacturers, the units are equipped with the latest type self-contained welding generators, powered by directly connected heavy-duty gasoline engines. The machines are mounted on pneumatic tired trailers with low centers of gravity, which permit towing in normal traffic speeds.

"THUMBS UP" for 1942

EVERYONE MUST DO HIS PART WELL!

The British have a stirring slogan for this war. "There'll ALWAYS be an England" are the words—and the upturned thumb gives dramatic significance to their declaration. The R. A. F., the Navy, the Tank Corps, all accept the "thumbs up" salute as a pledge of courage, determination, and unlimited sacrifice—even to life itself—for a sacred cause.

Now that the black cloud of war has unleashed destructiveness upon the property and people of the United States, let us accept the "thumbs up" determination of the English people as our pledge for 1942. With all our might and main let's work together, feverishly, to get our unwanted and unsought job over successfully, quickly and thoroughly.

Here is how we all feel at Pangborn's. Every ounce of manpower, every measure of strength, every resource in this fine plant of ours is placed at the disposal of our great government. We shall work together, men and management, day and night, each with our shoulder to the wheel, cheerfully, that the absolute justice of Democracy's belief may prevail to a certain victorious end.

We are rightly proud that our equipment helps industry grow stronger by the hour. We are PROUD of our Land, our Country, and our brave fighting sons at the Front. We stand solid behind them. With all our hearts and to the limits of our endurance we pledge 100 per cent "THUMBS UP" mobilization for 1942!

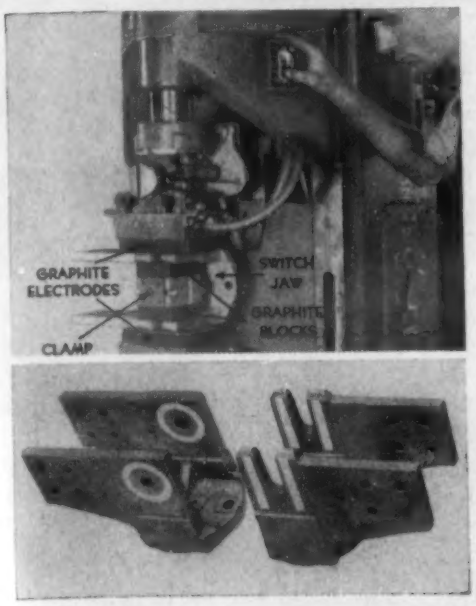
WORLD'S LARGEST MANUFACTURERS OF BLAST CLEANING AND DUST COLLECTING EQUIPMENT

PANGBORN

PANGBORN CORPORATION • • HAGERSTOWN, MD.

Electric Brazing

The growing demand for silver alloy contact materials in the construction of electrical equipment has necessitated the development of new techniques for attaching



these alloys to base metal parts of switch structures. The electric brazing process is proving of value in this connection.

An interesting illustration of the attachment of contact materials to heavy copper castings may be noted in the accompanying photograph of 4,000 amp. disconnect switch jaw and hinge to which strips and rings of silver-nickel contact material were brazed by the *Gibson Electric Co.*, Pittsburgh.

All of the contacts on each casting had to be brazed at one time; otherwise, the bonds of the contacts first brazed might be damaged by the heat required to braze the other contacts. To accomplish this, the contacts were placed on the casting and the casting held between graphite electrodes of a 50 k.v.a. welding machine, the outer contacts being held by these electrodes. The inner contacts were also held between graphite blocks, which were pressed against the contact material by means of the wedging clamp illustrated.

The brazing medium was silver solder, which had been applied as a solder flushing on the sheets of silver-nickel from which the contacts were made.

Portable Demagnetizer

A new, portable demagnetizer has been announced by the *Ideal Commutator Dresser Co.*, Sycamore, Ill. It is said to quickly demagnetize tools, drills, punches, dies and work held in magnetic chucks. Abrasive particles such as metallic dust, flakes, fine chips, etc., unremovable by other means, are removed after a single pass across the magnetic poles, according to the manufacturers.

Large parts can be demagnetized by moving the demagnetizer, which is light in weight, over the heavy, bulky work.

Welded Oxygen Tank

For sturdy, air-tight construction, an oxygen tank recently completed for the *Burdett Oxygen Co.*, Cleveland, Ohio, was completely arc-welded. Consisting of two shells—an inner shell inverted into an outer shell containing water—the tank is used for storing oxygen until such time as the gas is compressed into cylinders.

The sealing effect produced by the two shells is the same as when an inverted tumbler is set into a pan of water. The oxygen bubbles up through the water from a pipe located in the lower part of the outer shell, and is trapped in the air chamber between the surface of the water in the outer shell and the roof of the inner shell. The inner shell raises or lowers on rollers, depending on the amount of oxygen in the tank.

In preparing the roof of the inner shell for welding, the pre-cut steel plates making up the roof were laid out on trusswork for support and tack-welded at several points. A General Electric WD-34 d.c. welder and G-E Type W-20 electrodes were then used to weld the seams.

After all the seams of the two shells were welded, making the tank air-tight, the rollers which serve as guides when the inner shell is raised or lowered were welded to the top of the outer shell, at the "I" beam positions.

The outer shell of the tank is 25 ft. in diam., 8 ft. 6 in. high, and is fabricated from ¼-in. steel plate. The side and bottom of this shell were butt-welded; 2-in. reinforcing strips were welded under the bottom joints. The inner shell is 24 ft. in diam., approximately the same height as the outer shell, and is fabricated from ⅛-in. steel plates.

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Rectifiers and Tube Checkers

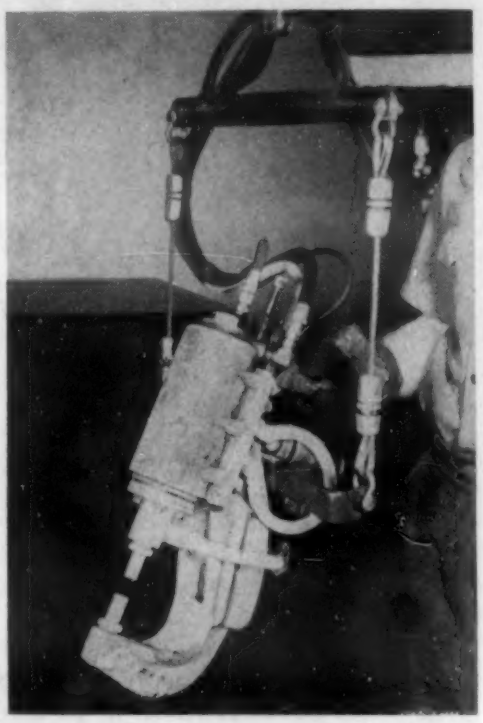
A self-contained tube checker for industrial type electronic tubes has been announced by *Weltronic Corporation,* Detroit. Provided with 7 sockets, the instrument, it is claimed, may be used to check almost every well-known make and type of industrial tube (except ignitrons).

Besides the tube checker, the same company reports a complete line of full-wave industrial rectifiers, ranging from 100 to 15,000 watt capacity. The rectifiers are designed for use in the operation of such devices as magnetic chucks, variable speed direct current motors, telephone switch boards, motion picture equipment, service station battery chargers, electroplating installation, circuit breaker reclosing mechanisms, industrial truck and railway car battery chargers, etc.

● A tiny brush, designed particularly for the aircraft industry but applicable to many other industries, has been developed by *Osborn Mfg Co.,* Cleveland. The little tool, used to clean a small area from around rivet holes, bolt holes, etc., is reported to speed up such work and make it possible for one man to do the work previously requiring seven.

Portable Welding Gun for Aluminum

As the result of demand from the aircraft industry for portable resistance spot welding equipment for tack welding and assembly welding of sections in fixtures where the work cannot be taken to



stationary pedestal welders, *Progressive Welder Co.,* Detroit, has developed a portable welding gun specifically designed for resistance spot welding of aluminum.

The new gun is air-operated, employing 2 differential cylinders in tandem, designed to produce a maximum point pressure of 1200 lbs. when using normal factory airline pressure.

For structural spot welding of aluminum, the gun will handle up to 2 pieces of .040-in. thickness. For tack-welding, greater thicknesses may be handled.

Meetings and Expositions

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual meeting. New York, N. Y. Jan. 21-23, 1942.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter meeting. New York, N. Y. Jan. 26-30, 1942.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, annual meeting. Philadelphia, Pa. Jan. 26-30, 1942.

INSTITUTE OF AERONAUTICAL SCIENCES, annual meeting. New York, N. Y. Jan. 28-30, 1942.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, annual meeting. New York, N. Y. Feb. 9-12, 1942.

The Worth of a Good Name is Manifest

It takes more than wishful thinking to meet emergencies. Today's defense requirements demand the finest materials and equipment that can be produced. Fortunate America to have available a host of unexcelled production units, large and small, whose very names are known throughout the world as unfailing guarantees of performance. The hand of American industry is at the plow. The furrow shall be completed!

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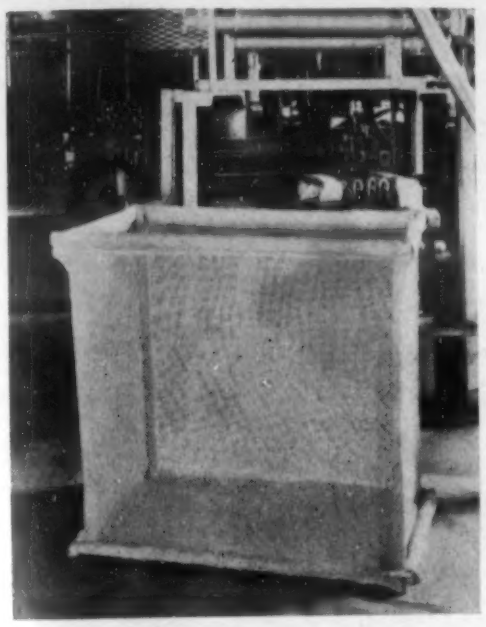
THE GLOBE IRON ROOFING & CORRUGATING CO.

BASIC OPEN-HEARTH ALLOY STEEL BILLETS AND SLABS

Plating Tank Nets

Plating tank nets as an aid in electroplating practice have been placed on the market by *Hanson-Van Winkle-Munning Co.*, Matawan, N. J. The nets are placed in plating tanks so that if any work is



dropped it will fall into the net and can be recovered by lifting the net out of the solution.

These nets can be used in nickel, cyanide copper, Mazic zinc, acid zinc and cadmium solution, but are not suitable for alkaline cleaners or sodium stannate tin solutions.

Gear Finishing Machines

Gear finishing machines, making available the crossed-axis principle of gear shaving for large gears, has been announced by the *Michigan Tool Co.*, Detroit.

By adapting the crossed-axis shaving principle to the finishing of large gears, such as those used in speed reducers for ships and large power plants, heavy machinery, machine tools, ordnance, etc., it is said that quietness, accuracy and service life can now be made comparable to those of smaller gears for which the process has been available for some time.

Due to the extreme accuracy of tooth form obtained when the shaving process is used, it is also often possible to maintain the same capacity even though the gear size is reduced, thus making possible smaller housings and more compact speed reducing units.

Automatic Machines for Cleaning and Finishing Small Parts

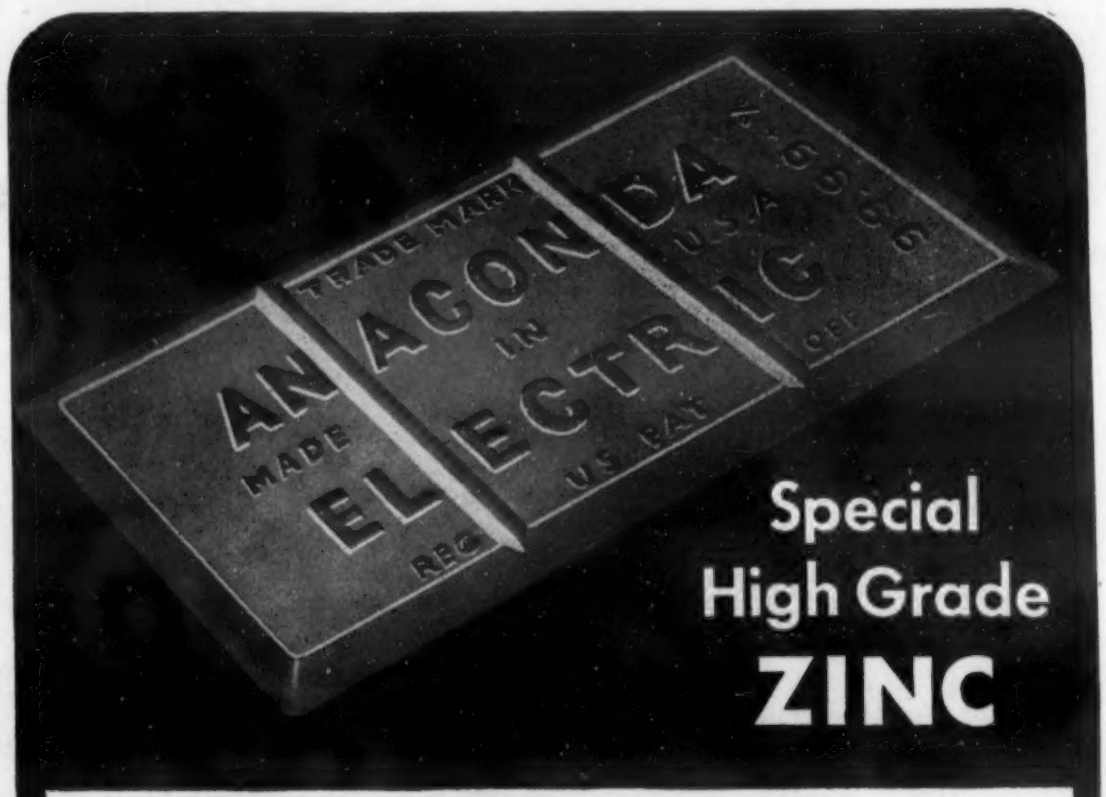
The development of a full automatic barrel cleaning and plating machine for handling small parts in bulk has been announced by the *Udylite Corp.*, Detroit. The machine is particularly adaptable to the processing of parts for ordnance.

Several such machines are being used to automatically zinc-plate machine gun clips in continuous production; machines are being used to handle 20 mm. brass cartridge shell cases as the latter are subjected to the various cleaning, rinsing and pickling operations. Other machines are being employed to zinc and cadmium plate aircraft engine parts continuously.

The manufacturer states that this new machine makes possible the complete finishing of small parts with absolute minimum of labor expense. The machine is completely automatic in that the parts are progressively subjected to the various cleaning, rinsing, pickling, plating and drying operations without manual handling.

The same company has also announced the development of a new automatic Parkerizing machine capable of processing large quantities of small parts. The machine is a hopper-type unit, air- or hydraulically-driven, according to the desires of the customer.

The parts are loaded in batches at one end and progressively transferred through the various dipping tanks required for the Parker process. The machine is fully automatic. No manual handling is required for the complete Parkerizing cycle including cleaning, rinsing, Parkerizing, rinsing, baking and oiling. Each batch remains a separate unit throughout the entire cycle, and one load cannot be mixed with another.



Guaranteed 99.99+% Pure

WHEN you choose Anaconda Electric for the base of Zinc die castings, you are certain of obtaining uniform, dependable metal. For every slab of Anaconda Electric Zinc is electrolytically refined and guaranteed 99.99+% pure.

Anaconda Electric Zinc is supplied in 50 lb. slabs clearly marked "Anaconda Electric 99.99+%." Whenever you use this well-known brand, whether in small quantities or carload lots, you may be sure that *every slab will test 99.99+% pure.*

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Furnaces for Tank Parts

The Selas Company, Philadelphia, last month was awarded the contract for some 14 large furnaces in multiple batteries, all of which will be direct-fired by gas through a multiplicity of individually adjustable ceramic radiant cups. The furnaces will be used by General Steel Castings Co., Eddystone, Pa., and Granite City, Ill., to perform the complex sequential heat treatment of the new one-piece cast alloy hulls and turrets of large (60 ton) and medium (29 ton) U. S. Army tanks.

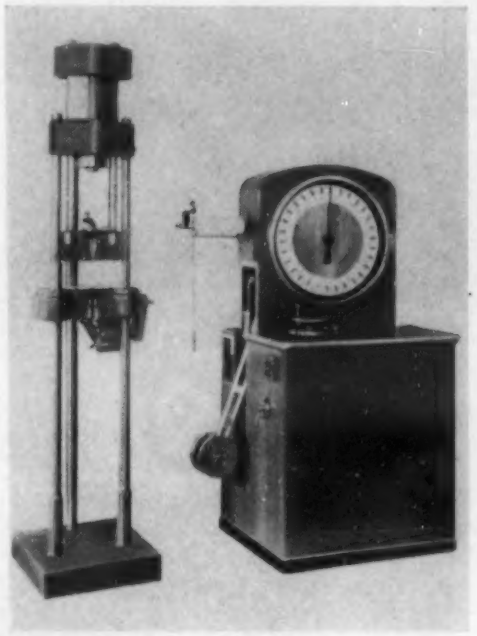
The furnaces are designed to meet the severe specifications covering heating uniformity and zoned full-proportioning control. Temperature variations which, in normal heat treating practice, would be considered as insignificant, would, in the case of the new armor plate, produce non-uniform and unacceptable armor. The difficulty of meeting such specifications is augmented by the fact that individual hull castings for the new 60-ton tanks may weigh as much as 25,000 lbs., may be as large as 22 ft. long by 10 ft. across, and may vary widely in contour and cross-section at various points.

An overhead monorail conveyor system above the furnace roofs will carry the castings through the final stages of heat treatment, and thus a minimum of conveying or mechanism metal will pass through the heating and cooling zones.

Over and above the needs of tank production, it is claimed that the partnership of new cast alloys with more uniform and accurate heat treatment will permit, in the future, considerable part elimination, design simplification and longer life of heavy metal products.

Precision Testing Machine

A new precision hydraulic testing machine, which should be of interest to wire and wire products manufacturers, was recently announced by the *Rieble Testing Machine Div. of American Machine & Metals, Inc.,* East Moline, Ill.



The machine is designed for capacities from 10,000 to 300,000 lbs., with a maximum separation of gripping heads of 40-52 in. (depending upon capacity) with the upper gripping head arranged in a convenient position of reach.

Accuracy, ruggedness, simplicity and reliability are insured, according to the designers, by the pendulum load indicator, since only two elementary quantities of weight and distance are to be measured in linear units.

Improved Forge Welder

Forging pressures up to 20,000 lbs. /in.^{2} are possible in a new pressure resistance welder just announced by *Progressive Welder Co.,* Detroit. The pressure is obtained through the incorporation of a motor driven hydraulic pump unit.

With this forge-welder it is said to be possible to obtain excellent welds, free of blow holes on hot rolled sections, without the necessity of removing scale or rust prior to the welding operation.

In operation, the forge-welder applies initial pressure to the electrodes. The welding is by current pulsations. Forging pressure may be applied either intermittently or continuously after the plastic state has been reached, according to the automatic control setting. Number of current impulses and the pressure cycle is adjustable to suit varying metal thicknesses, types of alloys, etc.

WAR MATERIEL IS NO MORE ACCURATE THAN THE GAGES THAT INSPECT IT•••

Marksmanship is the final link in making sure that the shell reaches its mark. All along the line, from specifications to the finished gun or shell, inspection of parts for accuracy makes sure that the gun will shoot as the marksman directs. Speed of inspection is of almost as great importance as accuracy. Federal Dial Indicators and Gages inspect accuracy of parts *with speed* and they *eliminate human variations.* Write for data on inspection gages for defense work to —

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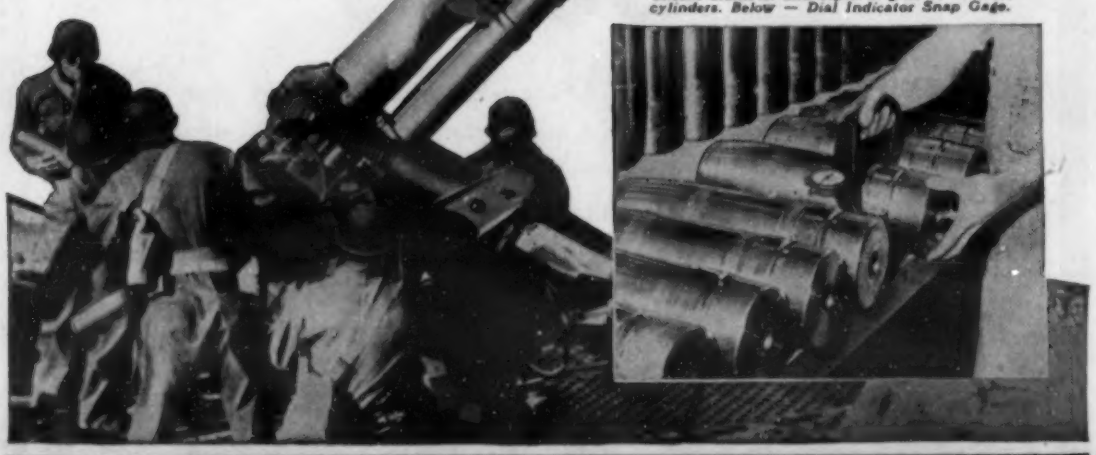
Checks both "lands" and groove diameter of various size gun bores.

Checks diameter and depth of grooves in recoil cylinders. Below — Dial Indicator Snap Gage.



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Microchemistry and Metal Surfaces

With the tiny tools of microchemistry *Westinghouse Research Laboratory,* East Pittsburgh, Pa., is studying the effects of oxygen, water vapor, sulphur, corrosion and tarnish, etc., on metal parts. In the laboratory, small flakes of rust and tarnish are measured in millionths of ounces. Tiny flasks, breakers, crucibles and test tubes are used; acids and other liquids are handled with a medicine dropper.

As an example of the work of microchemistry, it was discovered that film spots interfered with the operation of vacuum tube filaments. Analysis showed that bits of silica, or glass, from the tubes' bulbs had deposited on the filaments. This experiment called for the use of water to dissolve some of the chemicals, but extra pure water had to be distilled because the ordinary distilled water used in the laboratory had been kept in glass bottles and had dissolved enough silica from the walls of the bottles to confuse the measurements of the silica in the film sample. This special water had to be stored in platinum bottles to keep it pure.

Facts revealed in the microchemical laboratory have suggested many different ways to prevent spots on metal parts of machines. To keep oxygen in the air from reaching metal surfaces, some machine parts were placed in containers of inactive gases, such as nitrogen, and small parts were given the benefit of a vacuum devoid of all gases. Where these two methods were not practical, polished surfaces were coated with protective films of oil, grease or varnish.

To prevent the corrosive action of sulphur, phosphates and other foreign substances, it was possible to remove these substances from the air with the Precipitron—an electric air cleaner developed at the Westinghouse Research Laboratories. Air filtering with the Precipitron has been used to protect motors in steel mills and other factories, electric contacts of automatic telephone switching apparatus and precision tools in machine shops and scientific laboratories.

Electrons at 100,000,000 Volts

A new, powerful apparatus, called Rheotron by Dr. Kerst, its originator, which gives to electrons energy corresponding to 20,000,000 volts and also produces X-rays of this power, was announced recently by *General Electric Res. Laboratory,* Schenectady, N. Y. A new field for scientific exploration is opened by its production of a super-penetrating electron stream.

The Laboratory has already started work on a larger one, designed to give electrons an energy of 100,000,000 volts.

The Rheotron is a comparatively small device. The magnet is 5 ft. long, 3 ft. high, and 2 ft. wide. Electrons from a hot filament inside a glass vacuum tube, between the poles of a large electromagnet, are whirled around the tube and are steadily accelerated by electromagnetic forces until they attain a speed closely approaching 186,000 miles a sec., the speed of light.

Melting Furnace for Aluminum

The Ajax Electric Furnace Corp., Philadelphia, recently announced the development of a low-frequency induction furnace which makes possible the melting of aluminum and alloys on a full production scale. The furnace is described as having efficiencies between 77 and 80%, and of melting 5 lbs. /kwh.

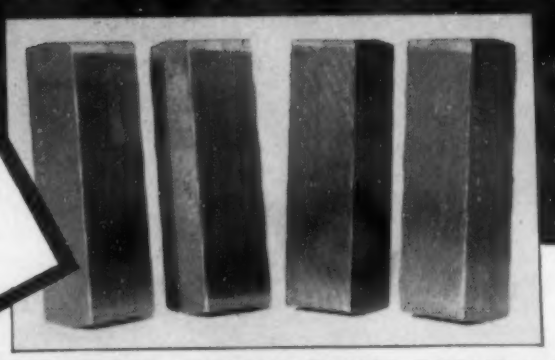
In this type furnace, the heat is generated directly in the metal at the bottom of the charge, thus preventing surface overheating. This is said to be of especial importance in the case of aluminum alloys, since they tend to absorb gases from the atmosphere at high temperatures.

The furnace is provided with pouring spouts, and with mechanical or hydraulic tilting means, in both nose-tilting and center-tilting types. It is said to be possible to attain a desired temperature for any particular type of aluminum alloy.

● An example of how a lot of little conservation efforts mount up to a significant saving is given by an office on Wall Street, where everyone saves the foil from their cigarette packages. In 9 months, four 1,000-lb. lots of tin foil were collected in that one building alone.

JESSOP WASHINGTON
WATER HARDENING TOOL STEEL

IDEAL FOR THREAD ROLLING DIES



AND OTHER APPLICATIONS REQUIRING A SUPERIOR CARBON TOOL STEEL

FOR threading low-strength, soft, and highly heat-conductive metals, straight carbon water hardening tool steel, such as JESSOP'S "WASHINGTON," is preferable to high speed steel—particularly for small threading dies. The ability of carbon tool steel to maintain a very keen cutting edge results in much longer runs and in a smooth, uniform thread.

JESSOP'S "WASHINGTON" straight carbon tool steel has been found highly satisfactory for thread rolling dies. It is easy to hob and shows little distortion or bow after quenching. On many jobs, dies made from "WASHINGTON" have threaded several million pieces before being replaced.

On other carbon tool steel applications where excellence of performance is the deciding factor, you can specify JESSOP'S "WASHINGTON" with the highest degree of confidence. For ordinary routine jobs, we will be glad to recommend other Jessop water hardening tool steels that cost less but will give outstanding service. Write for information.

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CARBON · HIGH SPEED · SPECIAL ALLOY · STAINLESS · COMPOSITE STEELS

Annual Meeting of the A.S.M.E.

Meetings, clinics and informal discussions concerned with the successful execution of the war production program featured the annual meeting of the *American Society of Mechanical Engineers,* held in New York City the first four days of December.

Metals and alloys, because of their number one position in the national effort to produce an ever-increasing flood of war materials, assumed a prominent position in the discussion at most of the sessions and much information of vital interest to the metallurgical engineer was presented.

Conservation and Reclamation Clinic

At an evening session, presided over by H. N. Davis, President of Stevens Institute of Technology, conservation and reclamation of materials in industry was discussed by an eminent panel of experts.

Four case histories were presented, two by representatives of large companies, and two by men representing relatively small concerns.

W. W. Finlay, Wright Aeronautical Corp., dealt with the case of how a large company reclaims and utilizes scrap materials. At the Cincinnati plant of the Wright Co., the reclamation program covers almost all the materials used in the production of the airplane motor.

The plant is a single story structure covering 35 acres of floor space and consists of machine, assembly and testing shops. Besides these, a large aluminum foundry is located in a separate, adjoining building. Each one of these divisions has a well organized system of scrap reclamation, and it includes everything from metals to burlap bags.

Perhaps the greatest portion of the reclamation program is centered on machine turnings and cutting oils. Here, for example, in the manufacture of one item, 18 tons of chips per day are collected and saved.

The method of collection and reclamation of chips and cutting oil is well planned and executed. Standard pans are made for all machines to collect the turnings and chips. When the pans are filled they are emptied into dump trucks made for this specific purpose, and taken outside where they accumulate.

At regular intervals, when enough scrap has piled up, it is removed to the oil-chip house. Here the machine turnings are subjected to a centrifugal process that separates them from the cutting oil. The extracted oil is purified and used over again; the turnings are properly segregated and subsequently are sold into the proper scrap metal channels.

How a small company handles the job of reclamation was presented by W. L. H. Doyle, engineer for Caterpillar Tractor Co. This company utilizes a separate and independent department employing about 50 men.

All small scrap—steel strippings, short ends of sheets, croppings, etc.—is saved and transferred to a special building for the purpose, where they are neatly piled according to type of material, size and shape. A careful inventory is kept of all scrap entering this building.

Before any new material is ordered for a particular item to be manufactured, the reclamation department is consulted as to the possibility of using any scrap materials. Wherever possible this miscellaneous collection of metal is used for small parts, such as stampings. Through this efficient reclamation system, 1500 different parts used about 2,000,000 pieces of reclaimed material last year.

Following the case histories on reclamation of materials D. R. Kellogg, Westinghouse Electric & Mfg. Co., and F. J. Allen, York Ice Machinery Corp., told how their companies have conserved vital materials by redesign, substitution, simplification and standardization.

In all programs of substitution, simplification and standardization, the engineers have been confronted with the problem of adjusting their product—its design and method of production—and moreover, they have been called upon to readjust themselves. No longer can the engineer have any material that fits best the service to which his product will be subjected. Now he must design with only a limited number of different materials available. In other words, he must design his product so that it will continue to meet service conditions when manufactured with perhaps inferior materials.

It was pointed out that the engineer has been able to meet the situation, and by redesign and painstaking effort has managed in almost all cases to retain the qual-

Check List of DURIRON EQUIPMENT for YOUR LABORATORY

Duriron equipment is installed in the laboratories of many industrial plants, research organizations, universities, hospitals and high schools. The extremely high resistance to corrosion, abrasion and scouring makes it ideal for the diversified uses of laboratory equipment. Besides the standard products listed below, special equipment may be made to your order.

DRAIN PIPE and FITTINGS: In sizes 1½" to 8". Installed as easily as extra heavy cast iron soil pipe.

SINKS and BOWLS: Rectangular and hemispherical shapes.

SINK STRAINERS and TRAPS: For use with porcelain and stoneware as well as Duriron sinks.

FLOOR DRAINS: In various types with outlet sizes 1½" to 6".

EXHAUST FANS: Not affected by fumes handled. Capacities up to 5,000 c.f.m.

EXPERIMENTAL KETTLES: Complete with jackets, covers and agitators.

WASHING KETTLES: Used for washing glassware with a hot chromic acid solution and for experimental work on small metal parts.

Send for Special Bulletins giving detailed information

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CORROSION-RESISTING DURCO ALLOYS & EQUIPMENT THE DURIRON CO. INC. DAYTON, OHIO

—Yet he holds the answer in his hand . .

SILVER DATA and RESEARCH . . .

The American Silver Producers' Research Project has for some years carried on a comprehensive research program covering silver and silver alloys for general and specific industrial uses. This research continues today under direction of Handy & Harman who specialize in supplying silver to the arts and industries.

A great deal of valuable data has been accumulated. These data are available to anyone interested in silver and its alloys for industrial application.

The full cooperation and research facilities of the Project are also offered for working out solutions to specific problems.

Silver — so familiar in articles of daily use — is often overlooked entirely as the possible solution of an industrial metal problem. Yet each year industry is using more and more silver.

And why this steady increase? The answer is plain — Silver excels other metals in properties that are important in many industrial products and processes.

Silver under most conditions is eternally durable. It is the whitest of metals and tops all others in resisting many types of corrosion. Silver is one of the most ductile and workable metals known. It is the best of all metals in conducting electricity and heat and has a high reflectivity. Silver also has excellent germicidal qualities and the salts of silver are photo-sensitive.

These properties make silver an industrial metal worthy of serious consideration whenever metal problems arise. Of importance, too, is silver's availability.

Familiarize yourself with the industrial uses and possibilities of silver and its many alloys through the service outlined at the left. If you have a metal problem which might be solved with silver, this service can give you valuable assistance. We invite you to use it.

AMERICAN SILVER PRODUCERS' RESEARCH PROJECT

Under Direction of Handy & Harman

82 Fulton Street New York, N. Y.

Have you thought of SILVER?

ity of the finished product. In instances where substitutions have resulted in somewhat inferior products, there have been no wilful attempts to hide or disguise the deficiency.

Following the four case histories, a clinic on the conservation and reclamation of materials in industry was conducted by Philip D. Reed, chairman of the Board, General Electric Co. Around the table sat prominent men from almost all branches of industry to answer any questions put to them. A running summary of the resulting discussion follows.

The fact was made known that each year 5,000,000 tons of scrap are available from railroads. In the public utilities field, 90% of all wire returned is salvaged and that in the case of one company 1,250,000 lbs. of wire was reclaimed in one year.

The Bell Telephone Co. is drastically cutting its use of vital metals by an intensive substitution program. Brass terminals have been replaced by soldered steel; silicon steel is being used instead of nickel alloys in pressed core rings, receiver coils, etc. This conservation program is resulting in significant savings of some of the strategic metals. Twenty-two % of the normal consumption of nickel is being saved, 74% of the normal aluminum consumption, and 21% in the case of zinc.

W. F. Drysdale, Director General of Industrial Planning & Engineering Dept. of Munitions and Supply in Canada, discussed briefly the system used in Canada for scrap collection. There the program is all centralized in the government. Two different means of collection are employed. For the gathering of the industrial scrap, the Canadian Institute of Secondary Materials is utilized. This is an organization of professional scrap men.

Local civic organizations are responsible for the collection of domestic reclaimable materials. All available volunteer help is used to separate and segregate the scrap.

Research, Designing, Invention, Education in the War Program

On Wednesday morning a very interesting session was held, in which research, designing, invention and education for the war production effort were each discussed.

Frank B. Jewett, President of the National Academy of Sciences, described the part played by research in our war program. He pointed out that very little had been done by modern science in war preparation up until the middle of the nineteen thirties. Since then, however, increased governmental appropriations have made possible considerable valuable research at several institutions throughout the country.

In June, 1940, the National Defense Research Committee, familiarly known as the N.D.R.C., was organized. It is made up of eight members, two being representatives from the Army and Navy, five selected from civilian ranks and well-known in scientific research, and the Commissioner of Patents.

The work performed under the direction of this committee includes research on armor, bombs and ordnance in general, chemical warfare, transportation and communication, submarine warfare, instruments, and numerous miscellaneous projects.

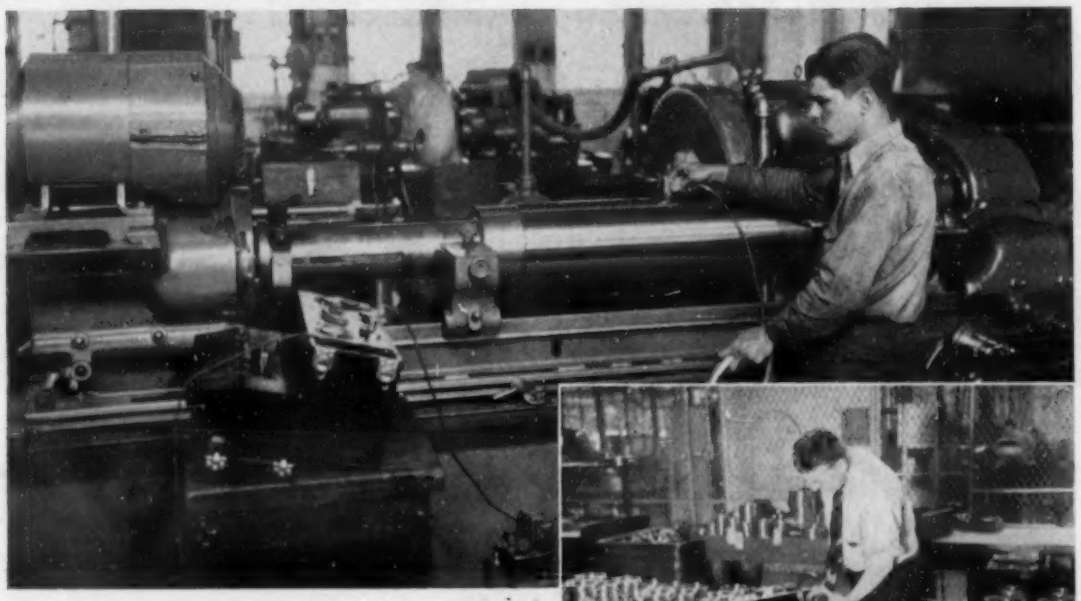
The projects are "farmed" out to various universities and industrial research laboratories all over the country. At present the number of different projects approved is around 550, while the number of institutions working on them is over 100.

G. M. Barnes, who is assistant Chief of Industrial Service, Research and Engineering, United States Army, capably reviewed the case of design in our war program.

In the 17 years prior to 1938 when war and armaments were forgotten words, the appropriation to the Ordnance Department averaged approximately $12,000,000 yearly, of which about one and one-quarter million was available for research and development. With some 1700 major items making up the modern fighting equipment, the development work made possible by this meager appropriation was limited. Nevertheless, Barnes said, when the emergency started the Department had numerous drawings and specifications of new material ready for issue to the manufacturers.

Many difficulties are encountered in the task of putting ordnance material into mass production by commercial manufacturing plants. To aid the conversion process, the Ordnance Department organized over a year ago some twenty-five engineering committees made up of representative engineers from industry. These committees usually met once a month to study, make suggestions, and revise the various designs of ordnance equipment. In this way

Profilometers Tell These Men What They MUST KNOW ABOUT SURFACE FINISH



IN any plant where precision finishes are being produced, there are a number of men who can use Profilometers to advantage.

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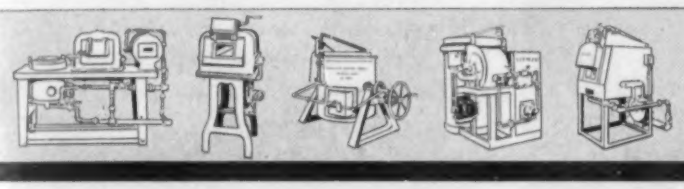

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many engineering improvements have been made.

The vital role played by the ordnance-manufacturing arsenals in the conversion of industrial manufacturing plants to war production was emphasized by Brig.-Gen. Barnes. The arsenal is the technical center of knowledge and this is available to manufacturers. In closing, he pointed out that this country will soon exceed all others combined in the mass production of ordnance equipment.

How inventions influence warfare and the continuous search for new inventions to outsmart the enemy was discussed by L. B. Lent, of the National Inventors' Council.

He pointed out that one has but to recall a few significant inventions to realize that the whole art of war changes as ideas for new war implements emerge. The invention of gunpowder is an example, and in more recent times, the development of the airplane.

In times of emergency the number of inventions submitted by the public for governmental use increases to such an extent that a special agency is needed to do the job of carefully considering each invention or idea. The National Inventors' Council was created for that purpose.

The primary purposes of the council are to encourage the public to submit inventive ideas having any possible value, and to promptly examine these inventions for their potential usefulness.

Of the many ideas and inventions received, most of those found useful have come from members of the technical professions, and it was urged that the flow of usable inventive ideas be not only continued, but increased if possible.

In the final talk of the session, A. A. Potter of Purdue University and Expert Consultant, U. S. Office of Education, reviewed the subject of training and educa tion for war production work.

Early in the spring of 1940 the need for millions of skilled workers and large numbers of engineers for defense work became apparent. The trade schools, vocational schools, and engineering colleges were selected to train these necessary and vital men.

In the case of training men for engineering work, it was stressed that no attempt is being made to turn out fully trained engineers or scientists, but rather by intensive courses to prepare people for specialized technical tasks.

Even with the large numbers of specially trained men being turned out through the educational program, the shortage of engineers, scientists, and production supervisors is bound to be serious for a long time. The most prominent need at the present is for industrial production personnel on the higher levels. To train such supervisory personnel will require close cooperation between industry and the educational institutions of the country.

Industry and the Arms Program

Speaking at the annual dinner, Donald M. Nelson, Executive Director of the Supply Priorities and Allocation Board, stressed the great importance of the U. S. industry in the outcome of the world struggle.

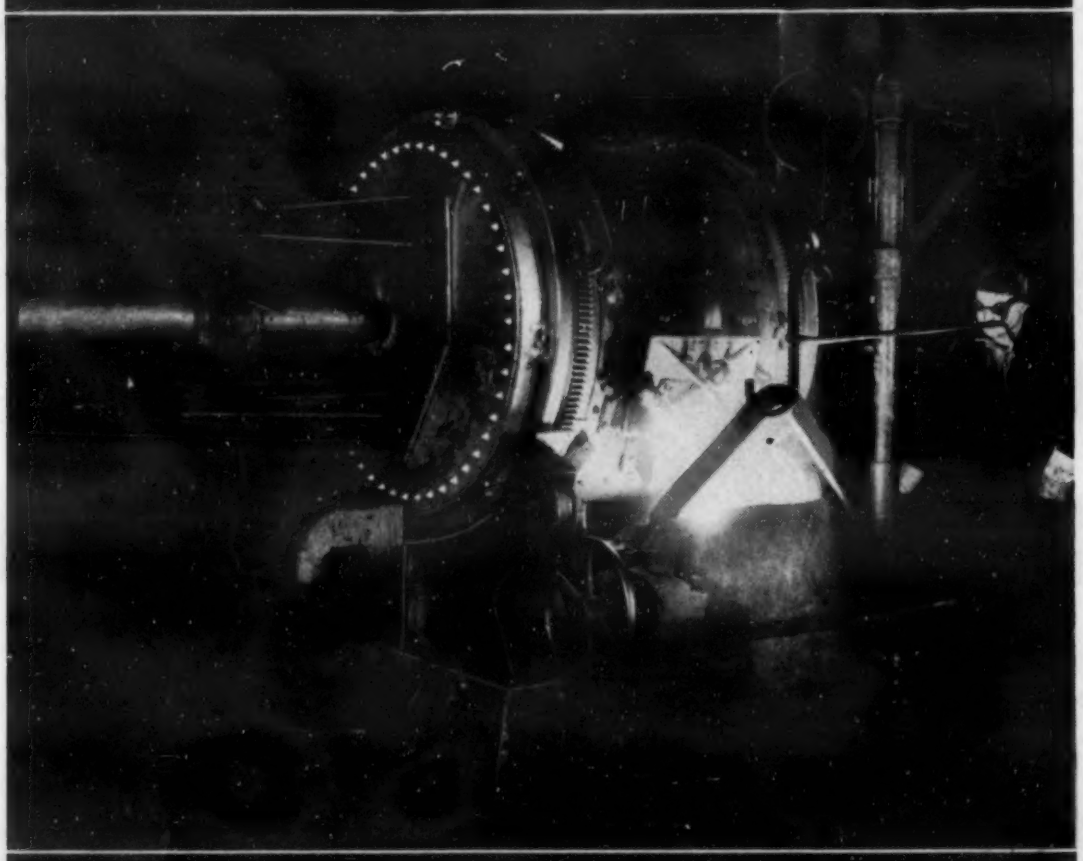
Design is the basis for the best use of materials, he remarked. With the rapid progress of scientific research there are innumerable opportunities for new combinations of materials, and new applications of knowledge to help us make the very best possible use of our available materials.

In the field of conservation and substitution much has already been accomplished. Hundreds of government specifications have been revised to reduce or eliminate the use of such critical materials as aluminum, chlorine, chromium, copper, etc.

Industry, too, he added, has been active in conservation and substitution. The use of vital metals in household products has been reduced to a minimum. There have been changes in design to cope with the conditions; simplification and standardization have resulted in large savings. Avoidance of manufacturing waste has been an important item in the conservation of materials.

But even with the utmost that can be done in the way of conservation, he pointed out that the material shortages are still acute. To combat them, the supply of all these materials must be increased wherever it is possible. To do this industry must adopt an engineering attitude. That is, the question of what is the maximum production which it is physically possible to achieve, must be considered. The ordinary standard of profit and loss must be disregarded and the physically possible maximum production must be the resolved aim of all industry.

Speeding up Production for World War II



Designed during World War I to effect savings in labor and metal losses, and to get the utmost production from available plant space, Detroit Rocking Electric Furnaces are again today a vital factor in speeding up the production of defense materials.

With a Detroit furnace you get accurate control over temperature and composition. You get fast melting; a uniform dependable product; ease of control and improved working conditions. For all around economy you simply cannot beat a Detroit Rocking Electric Furnace. Write us about your melting problems.

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METALLURGICAL ENGINEERING shop notes

Water-Cooled Forging Furnace Doors

By J. O. G. Gibbons

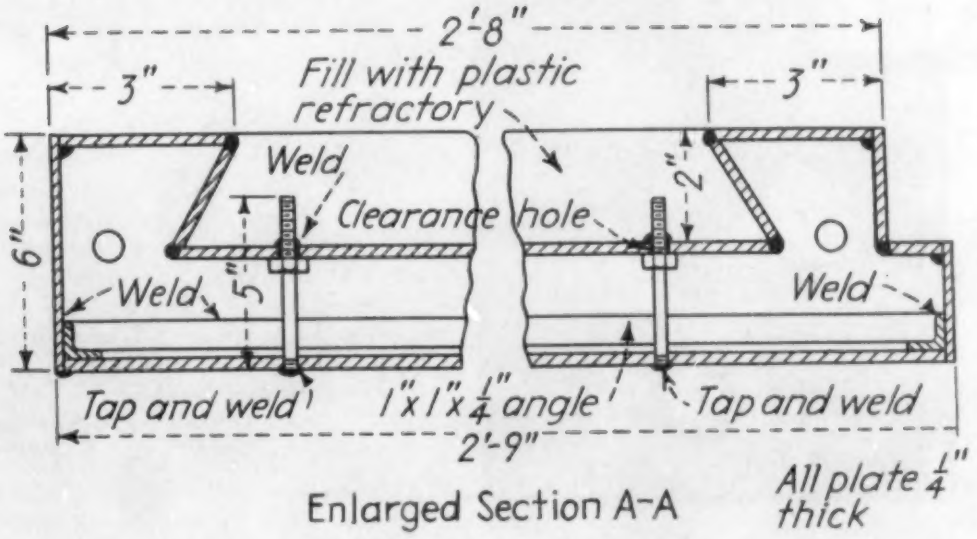
The accompanying sketches illustrate the design of a pair of water-cooled doors recently installed on a forging furnace, and which would be suited to other furnaces of a similar type. The actual dimensions of these particular doors are given in order to clarify the design. However, doors of similar design can be made to any desired dimensions to conform with the size of the furnace.

As will be seen from the sketch, the inner faces of the doors, except for a 3-in. space all around the outside, have a 2-in. thick panel of plastic refractory. Any refractory plastic on the market that is suitable for boiler setting work should be satisfactory for the purpose.

The inlet pipe enters at the top and follows down the side and across the bottom of the doors. The pipe along the bottom has a number of holes drilled at regular intervals through which the entering cold water can escape, circulate about and cool the hot doors. The cooling water is discharged without resistance into the open end of a 1½ in. overflow outlet pipe at the top of the doors above the inlet. Thus, there is no opportunity for air to become pocketed in the doors and cause overheating or warping. There should be no valve on the outlet.

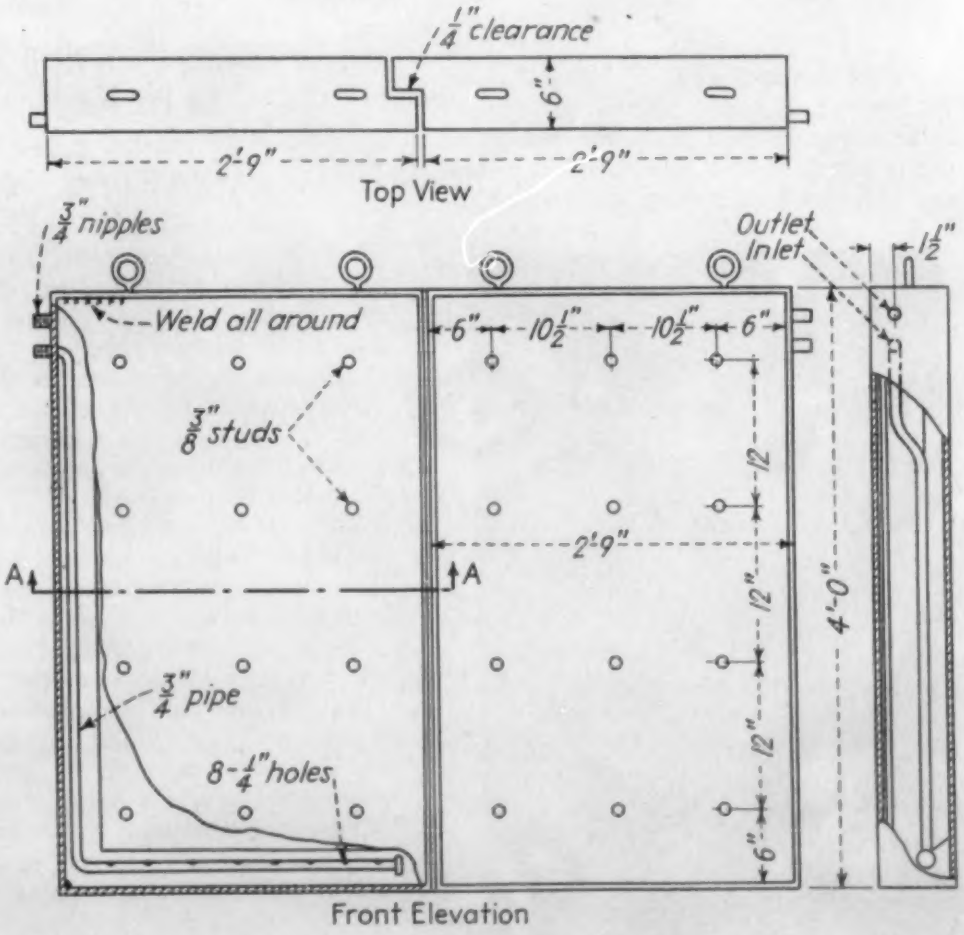
The discharged water is drained to a sump. In this particular installation, it is intended to use the discharge water for boiler feeding, which makes possible the conservation of both water and heat.

With this arrangement, the pressure in the doors cannot exceed that due to about 4 ft. head of water in the doors themselves. This is an important safety factor. Only recently a serious explosion occurred in a water-cooled flue damper. This would have been impossible if the illustrated method of discharge had been used.



Enlarged Section A-A

All plate ¼" thick

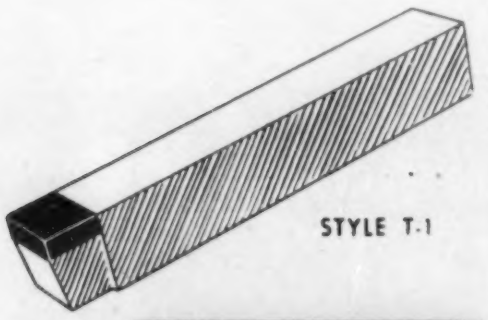


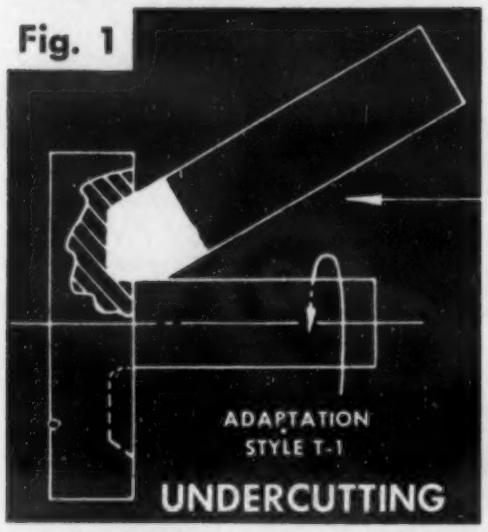
(MORE SHOP NOTES ON P. 124)

Converting Standard Tools to Special Shapes

by K. R. Beardslee
Carboloy Co., Inc.

Under present conditions, with cutting tool producers swamped with orders, time delays in obtaining tools, particularly special tools, have become somewhat aggravated. It is possible, however, to ease the situation considerably by purchasing standard tool styles wherever possible, and by making and retipping the tools.



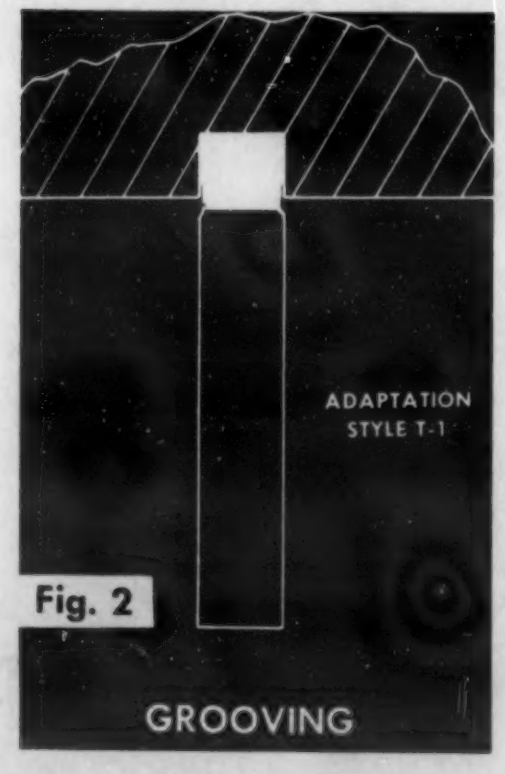


At the Saginaw plant of Baker Perkins, Inc., where iron and bronze castings are made, many different machining operations are required, and an unusually large number and variety of cutting tools is needed. Often the tool shanks or the tips must be especially shaped to fit them for working in difficult positions, or on unusual shapes. To meet this situation, the shanks are either made and tipped right at the plant, or a complete standard tool is purchased.

The tool may first be used in its initial shape for a time or reground to a special shape immediately to suit some unusual requirement. After the job requiring the special shape is finished, the tip may either be ground to a standard shape or the shank may be retipped and the cycle repeated. When the tip becomes too short for further use, the shank is remilled and a new tip inserted.

By the process of regrinding and reforming the tips and shanks, the total number of tools required is reduced and, besides this, the ability to utilize standard tool shapes insures more rapid delivery from the tool manufacture.

The accompanying illustrations show examples of how a standard carbide-tipped tool can be applied to special machining operations. In this case the standard tool has been converted to perform a special under-cutting operation and by another variation, has been made suitable for grooving.



To obtain the greatest possible savings with cemented carbide tipped tools, proper regrinding, before they become dull to the point of failure, is essential. The continued use of a dull tool (of any type) results in increased pressure on the tip and greater power consumption, as well as danger of tool breakage.

—"Grinding Carbide-Tipped Tools,"
Norton Company

Correcting Misspelled Words on Die Molds

by Adolph Bulaw
Bulaw Welding Co.

A washing machine dial mold part which had been incorrectly engraved was neatly corrected by the use of welding. In the accompanying photograph (furnished by Hobart Brothers Co., Troy, Ohio), the die mold part is shown with the incorrect engraving circled. The job was to eliminate the incorrectly spelled "Overhalls" so that the proper word, Overalls, could be re-engraved.

To alter the dial, the "Overall" section had to be built up without touching the division brackets. The raised brackets were 1/32 in. high and 1/32 in. wide.

If the welding arc touched these brackets, they would be undercut and very difficult to correct. For instance, if the bracket were hit by the arc, the bracket would have to be built up high enough to be recut and this would result in an almost certain damage to the letters. So the weld for this mold had to stop short of the "ETC." without touching the raised bars on either side.

Preparations for welding were simple. The mold was covered with asbestos, with a hole cut in it just large enough to permit welding on the problem area. The letters were chiseled off very carefully and the entire mold heated to 350 deg. F. The exact pre-heating was necessary so that the steel mold would not become porous.

A single bead was welded over the letter with an ordinary 3/32-in. mild steel straight polarity electrode at approximately 50 amps. After the welding operation, the correct word was easily re-engraved.

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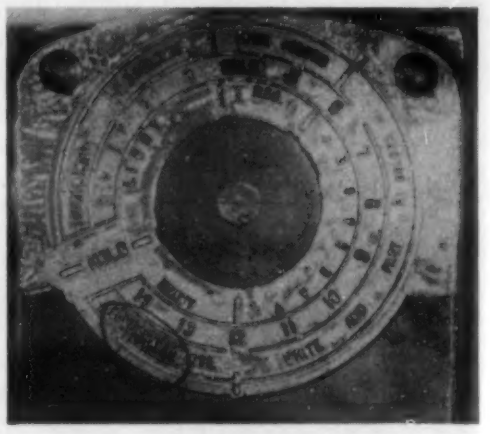
There comes a time in every man's life when he feels the urge to write. When you get that urge, just sit down and dash off a SHOP NOTE and send it to METALS AND ALLOYS. *If it is a practical, helpful item, the chances of seeing your "brain storm" in print are excellent. Besides, we pay cheerfully for all original SHOP NOTES published.*

Incidentally, for those who never get the urge to write, you might have a practical problem that some other reader could answer. We expect to run such problems in this department from time to time, and expect to get lots of answers.—The Editors.



In pack hardening high-carbon high-chromium tool steels in cast iron borings, the borings may be prevented from sticking to the tools by wrapping each tool in brown wrapping paper before packing. The paper will prevent the borings from adhering to the tool, and upon opening the pack, the charred paper will fall away and not interfere in the least with quenching.

—Service Bulletin,
Carpenter Steel Co.

The metal-spraying of wooden (white pine) patterns in the foundry has resulted in some cases in 20 times the pattern life obtained from ordinary shellac-finished patterns. The glaze-removed pattern surface is metallized with about 0.005 in. of zinc to seal the pores, followed by 0.025 in. of aluminum or bronze. The metallized surface is then sanded or buffed to the desired finish and placed in service.

—Metallizing Co. of America, Inc.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

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Some Interesting Foundry Trends

"Recent Foundry Developments Reviewed." *Foundry Trade J.*, Vol. 65, Oct. 30, 1941, pp. 281-282. Review.

Attention is called to the necessity of evolving sand testing methods that can be used as sound bases of specification and arbitration. British as well as American workers are working on these problems, as opposed to purely control testing.

While hot blast cupolas, introduced by the Germans, have not been successful in English practice because of short heats, American workers, such as Vial and W. D. Moore and others have applied the principles successfully to long-time large-scale melting in the United States.

Among the methods tried for reclamation of cast iron borings and chips is to charge them in the last of the cupola run and pig. Buchanan has poured liquid metal on tinnings and rotated them to evolve a meltable mixture. [*George Elliott of Lunkenheimer did much the same thing in the course of some of his duplexing experiments in 1917.*—J.W.B.]

The Swiss have charged a mixture of coke, steel turnings and ferro-silicon in an open top cylindrical furnace and immersed an electrode in the mixture. With current on melting is accomplished and fluid metal drawn off the bottom.

The use of the "electric eye" brings the Bessemer back into the picture.

P.M.G. (special silicon bronze) has been found equally or more suitable than Admiralty Gunmetal (88-10-2) for many uses.

Hydro-blast usage is just beginning in England.

The Eaton-Erb method of permanent mold casting appears attractive for certain applications. It is used in Russia, as well as in the Detroit district, where it was first developed. JWB (1)

1a. Ferrous

Electrolytic Zinc-Coated Wire

"Electrolytic Zinc-Coated Wire." L. H. Winkler (Bethlehem Steel Co.) *Wire & Wire Products*, Vol. 16, Nov. 1941, pp. 687-693, 712-715. Descriptive.

On account of the protection against the corrosion of steel which zinc coatings offer, much research and effort has been given toward the improvement of those coatings and methods of applying them.

The Bethanizing process, developed from the basic methods of U. C. Tainton, is a process for producing electrolytic zinc-coated wire. It is distinct from the older electrogalvanizing processes in that no metallic zinc appears in the system until it is electrolyzed from the solution in the form of virgin zinc on the wire as a finished product.

There are several important differences between Bethanized coatings and those coatings produced by the hot dip methods. The ductility of the Bethanized zinc coating is perfect, because of the absence of impurities and the harder and more brittle zinc iron alloy, which is present when steel is galvanized by the hot dip process. The perfect bonding which results from the cleaning methods and characteristics of the electrolytically deposited zinc makes possible fabricating operations on extremely heavy coatings. It is possible to zinc-coat any type of steel wire and thus obtain a greater range of physical properties than could be realized by the hot galvanizing methods.

The Bethanizing process consists of two

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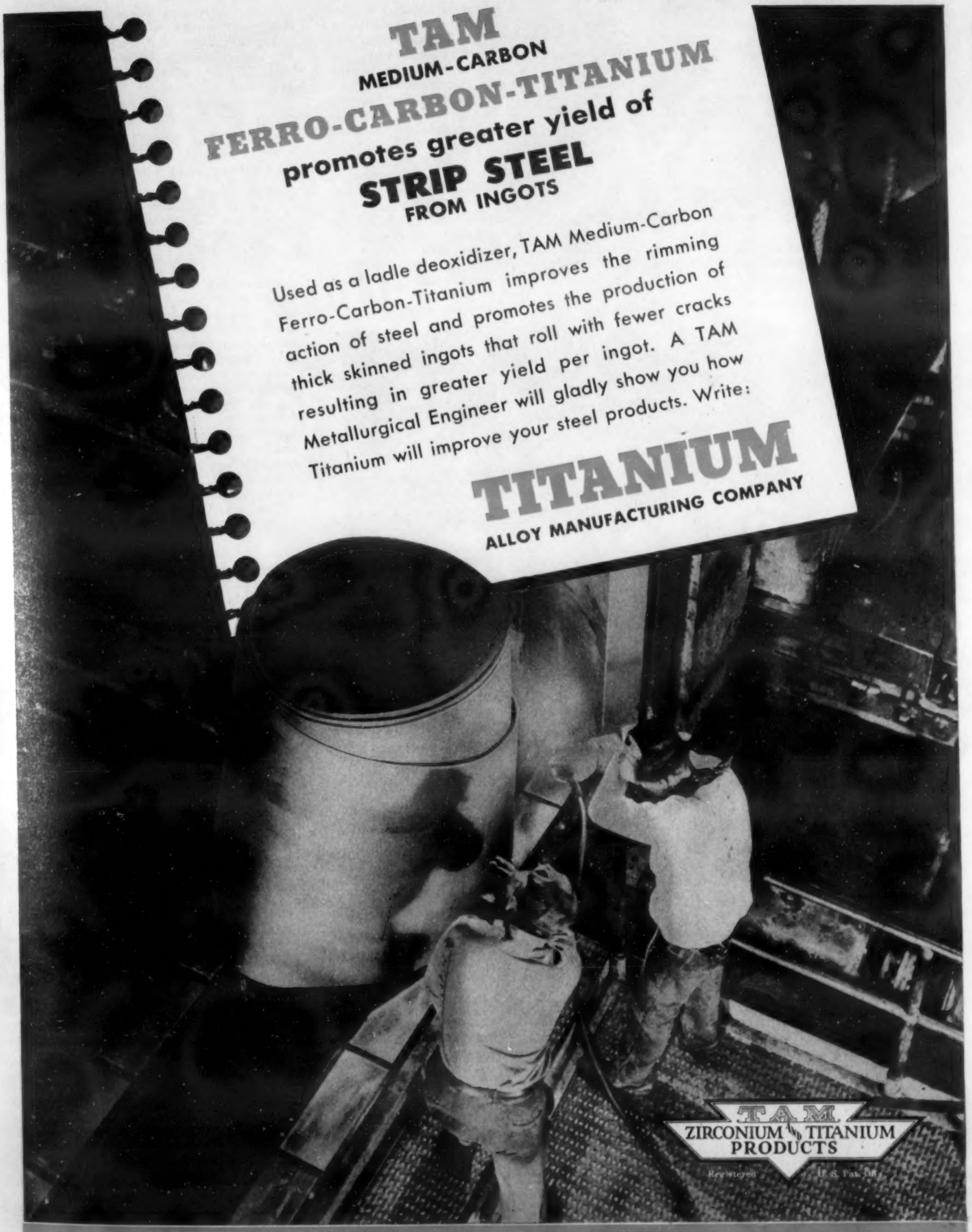

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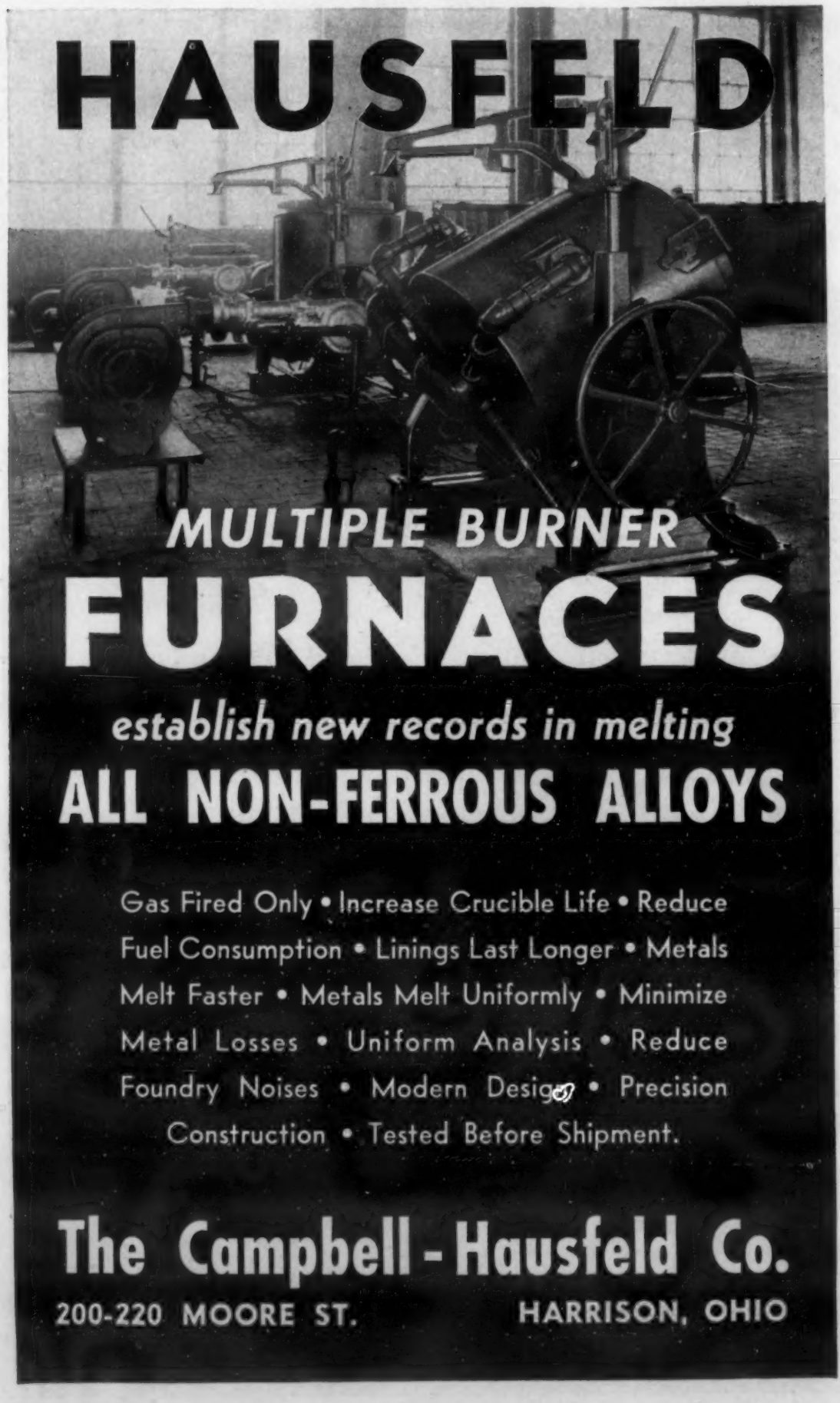
principal stages: a chemical extraction plant and a plating plant. Calcined zinc concentrate is brought into the chemical extraction plant where it is given a leaching treatment. It is dissolved by free sulphuric acid present in the used plating solution, which is returned to the leaching plant. The iron present in the ore is precipitated and removed by a filtering process along with other impurities. The resultant filtrate is a very concentrated zinc sulphate solution with small amounts of copper, cadmium, antimony, etc., which are removed by treating with zinc dust. The result is a very pure neutral electrolyte for the plating process.

Before application of the electrolytic zinc coating, the wire is generally annealed and cleaned electrolytically. After the annealing, the wire is rinsed in an acid solution where again it is treated electrolytically. The wire is then passed through the plating cell, in which there is a very high acid solution with high electrochemical efficiency at elevated current densities.

The resultant electrolytic zinc coating that is formed has a uniform structure continuous from the surface of the steel to the outer surface of the coating. From the electrolytic plating tank the wire is passed through rinsing baths and then polished, usually with a burnishing machine.

The applications of this special zinc-coated wire are numerous. It is used for merchant wire products, such as fence and barb wire, nails and staples; for high strength galvanized rope and cable wire; for heavily coated telephone and strand wire; for woven wire products, such as chain link fence and conveyor belts; and for chain products, such as pump chains. A large quantity is used for drawing into very fine wire, which is later used for screen cloth and air-cleaners. HRC (1a)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Low-Frequency Furnaces for Steel

EXPERIMENTS WITH THE LOW-FREQUENCY FURNACE OF ROHN ("Versuche mit dem Rohn-Niederfrequenzofen") A. NIEDENTHAL & H. WENTRUP. *Tech. Mitt. Krupp Forschungsber.*, Vol. 4, June 1941, pp. 135-150. Experimental.

Recent experiments with the Rohn low-frequency induction furnace are described. The furnace (first described in 1934—see *Stahl und Eisen*, Vol. 54, 1934, pp. 77-82) has an iron core and can be used at ordinary frequencies.

Instead of a circular trough for the melt, the Rohn furnace has a crucible-like melting vessel in which mixing of the melt is achieved by rotation of the bath before each magnetic pole of the furnace winding and by a slow rotation of the whole bath around a vertical axis as well. These movements mix the slag and melt intimately and accelerate the reaction between the two.

The new experiments with steel melts confirmed that the reactions between the melt and alloying elements or other additions can be carried out quickly in this furnace, particularly through the thorough heating of non-metallic substances. Difficultly melting slags, such as high-silica silicate slags or calcium and alkali-rich slags become very liquid.

The motion of the bath also causes a stronger reaction with the air and greater nitrogen absorption, so that if desired, nitrogen-rich chromium or chromium-nickel steels can be made. Deoxidation by aluminum, silicon, etc. occurs not only by "washing out" the oxygen by the slag, but by a "precipitation deoxidation" in the steel as well, with the formation of either solid or liquid reaction substances.

On the other hand, the motion of the bath has the disadvantage of increasing the reaction between the slag and the furnace lining. The electrical efficiency of the furnace is also rather low (about 12½-20%) because of higher losses by conduction and radiation and by electrical transformation; these might be reduced by better electrical and mechanical design. The energy consumption was about 250 kw./ton at 2800-2900° F.

Metallurgical processes that require a high FeO-containing slag cannot be carried out in this furnace as such slags attack too strongly the basic linings at present available, and an acid lining is also unsuitable for reduction processes. The most suitable basic lining was found to be a magnesia-zirconium oxide lining, which did not slag so much as a pure magnesia lining and had the additional advantage that it could be tamped in with a templet in the wet state and heated with a compressed air burner up to 1800-2000° F. Ha (1a)

Welded Ladles

"WELDED LADLES FOR OPEN HEARTH SERVICE." F. L. LINDEMUTH (William B. Pollock Co.) *Steel*, Vol. 109, Nov. 24, 1941, pp. 74, 76-77. Practical.

For ladles of 60 or 70 tons capacity and larger, the weight of a riveted ladle is about ¼, and that of a welded ladle about 1/6, the weight of the molten metal car-

"695"

The Ready-to-use plastic for a dozen hot repairs

IN more than 60 steel plants, open hearth operators are reducing furnace delay time by using 695 Plastic for a wide variety of hot repairs.

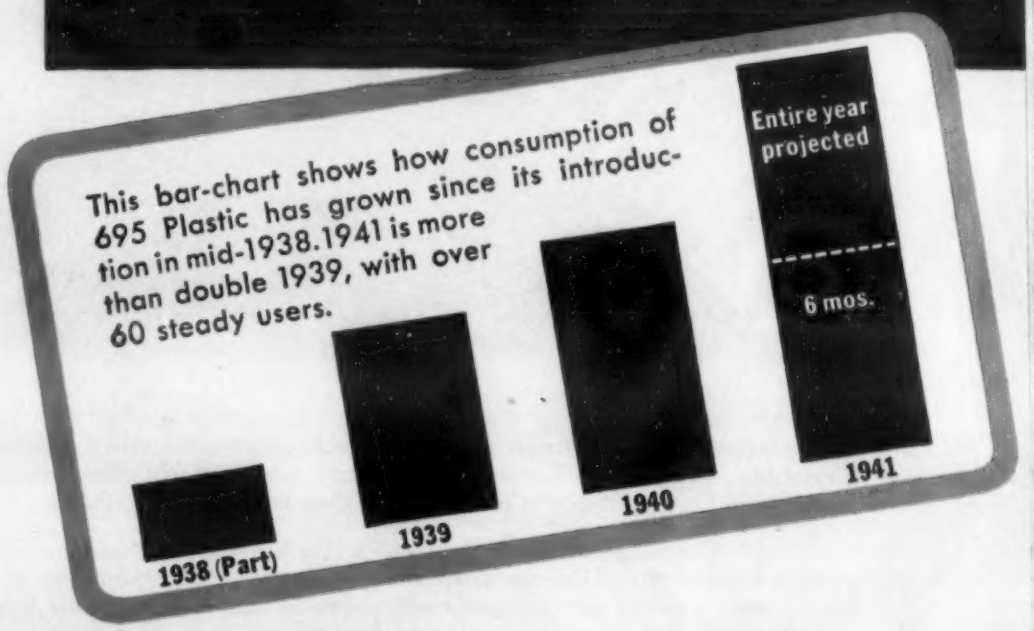
695 is a well-balanced plastic refractory composed of chemically treated magnesite, high-grade chrome ore and suitable laboratory-developed bonds. It sets quickly with an extremely hard, dense, monolithic structure and has a melting point well above 3600° F.

Here are a few of the more important uses:

1. **To build and repair tapholes.**
2. **To line open hearth runners.**
3. **To line electric furnace spouts.**
4. **To patch open hearth front walls.**
5. **To patch backwalls at skewbacks.**
6. **To patch monkey walls.**
7. **To cap and face bridge walls.**
8. **To repair port floors.**
9. **To repair air uptakes.**
10. **To repair soaking pits.**
11. **To repair mixer linings.**
12. **To patch firecracks in ingot molds.**

Every month brings reports of other applications, too, where operators are using 695 with success. If it is new to you, our service engineers will be glad to assist you with it.

A few bags of this dependable magnesia-chrome refractory stored conveniently in the open hearth department may save you valuable hours of production time. Try it!


This bar-chart shows how consumption of 695 Plastic has grown since its introduction in mid-1938. 1941 is more than double 1939, with over 60 steady users.
Entire year projected
6 mos.
1938 (Part)
1939
1940
1941

Basic Refractories for the Steel Industry:

MAGNEFER—Dead-burned dolomite for hearth and slag line maintenance.

SYNDOLAG—Dead-burned dolomite, smaller in grain size than Magnefer.

BASIFRIT—Quick-setting magnesia refractory for new construction, resurfacing and general maintenance.

GUNMIX—A basic refractory with chemical bond, sized for use with a cement gun.

RAMIX—An air-setting basic refractory for rammed hearths and cold furnace repairs.

695 PLASTIC—Strong plastic with basic and neutral properties, for hot and cold repairs.

OHIO MAGNESITE—Domestic dead-burned high-magnesia grain refractory, equal to Austrian.

HEARTH PATCH—For deep hole patching and other quick repairs in the basic open hearth.

BASIC REFRACTORIES, INC.

FORMERLY BASIC DOLOMITE INC

CLEVELAND, OHIO

ried. The welded ladle is lighter than riveted construction only with ladles of 60 or 70 tons capacity and over.

For these capacities, riveted ladles are generally made with cast steel spacers extending from trunnion casting to trunnion casting. Such spacers are not required for welded ladles. The ratio of the weight of a welded ladle of ordinary proportions to the weight of molten metal carried is fairly constant in all capacities from about 50 tons up. Round ladles with the height slightly greater than the diameter up to a height of 11 or 12 ft.—about 125 tons capacity—are preferred.

To keep down the head of metal during pouring, the height of the larger ladles is kept at 11-12 ft. and only the diameter is increased. When increasing the capacity of the ladles where the center-to-center distance between trunnions and the height cannot be changed, the ladles are made elliptical. The sides of elliptical ladles may be either straight or curved to a radius up to 12-15 ft. Curved sides will give longer life of linings.

Ordinary low-carbon steel is the safest and most economical material for the shell. A good material for the trunnions is ordinary 0.30% C steel, annealed.

The diameter of the trunnions should be 10 in. for a 50-ton ladle, and increase to 16 in. for a 175-ton ladle. For stability of the vessel while in the crane hooks, the trunnions should be about 15 in. above the center of gravity of the full ladle for a ladle 12 ft. high. As the center of gravity is toward the pouring side, the trunnions are set toward the pouring side of the ladle.

The best construction for the bottom is a flanged and dished plate of proper proportions to carry the weight and pressure of the molten metal with an ample factor of safety. The bottom is sloped toward the tap-hole, which should be reinforced in the same manner as the holes in a pressure vessel.

To prevent buckling and cracks from heat radiated from the ingots, a separate removal plate bolted to the bottom and spaced away from it with washers, is used. The spout should be of ample width and depth, located on the ladle so that the slag enters it easily, and long enough to discharge directly into the slag-pot.

The lining can be laid directly against the sides of the welded ladle. The average thickness is about 7 in. in the top half and 9 in. in the bottom half of the sides, and 9-11 in. on the bottom. MS (1a)

THESE two tanks in the plant of Carnegie-Illinois Steel Corp., Duquesne, Pa., were lined with two courses of acid-proof brick laid entirely in Penchlor Acid-Proof Cement.* They are used for pickling steel bars where the mechanical as well as the chemical action is especially severe.

Due to their large size—45′ x 5′ x 4′—both tanks were built with expansion joints in their lining. Inspection after a year's constant use showed absolutely no signs of permanent expansion of the lining. Both bricks and cement are still in perfect condition.

This is typical of the way Penchlor Acid-Proof Cement stands up in tough service. It is inert to all acids except hydrofluoric. It adheres strongly to such materials as brick, steel, glass, carbon, lead, and rubber. Quick-setting and self-hardening, it speeds up acid-proof construction.

For extremely abrasive conditions, or where thermal shocks are extreme, Asplit Cement* provides utmost durability and prevents spalling of bricks. It is a synthetic resin that far outlasts other types of acid-proof construction.

Penn Salt has been engaged for a great many years in the manufacture of acids and alkalies. We have naturally had considerable experience in the use of cements to resist corrosion, and are in a position to give technical advice. We will welcome inquiries on your problems.

*Fully protected by *existing* patents.

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Air Conditioned Blast Furnace

"Six Months Operating Experience with Modern Air Conditioning Equipment on a Large Blast Furnace." E. K. Miller (Jones & Laughlin Steel Corp.) *Blast Furnace Steel Plant*, Vol. 29, Nov. 1941, pp. 1103-1107; also, *Steel*, Vol. 109, Nov. 10, 1941, pp. 88, 91, 94, 112-113. Operating report.

The benefits obtained by equipping one of the blast furnaces at the Aliquippa Works of the author's company with a 3-grain pre-compression chilled-water air-conditioning system are presented. The furnace has 28½ ft. hearth diam., 90 ft. stack height, 30 ft. bosh diam., and 18 tuyeres.

During the first 6 months' operation with air conditioning (Apr.-Sept. 1941), the average monthly production of iron was 8.22% greater and coke consumption was 3.03% less than the monthly averages for the year 1940. For June-Sept. 1941, iron production was 16.07% greater, and for June-Aug. 1941, coke consumption was 4.26% less than for comparable months in 1940. The furnace operates more smoothly, drives more regularly, and keeps a more constant wind blowing, more uniform heat, and a more uniform burden, resulting in a more uniform temperature and composition of iron.

To confirm these results, conditioned air was transferred from the original furnace to another one of the same size during the first half of September and again put back on the first furnace during the second half of the month. For the first 13-day period, production of the original furnace decreased 14.5%, while that of the second furnace increased 13.9%. During the second half of the month, the first furnace, with conditioned air switched back to it, recovered the production lost, while production of the second furnace decreased correspondingly.

During the first 6 months' operation, the steam saved on the turbo-blower in blowing the furnace on air conditioning was equivalent to a saving of 2,900,000 kw.-hrs. This more than offset the operating cost of the air conditioning unit, after taking into account the loss of heat in the air entering the stoves. It is expected that when including the winter months, the average increase in production throughout the year will be at least 8% and the decrease in coke consumption will be about 4%.

Some think that it is necessary to reduce the moisture to 1 grain to obtain any real benefits, but the results stated above indicate that a greater percentage of the maxi-

The ATLAS MINERAL PRODUCTS COMPANY

OF MERTZTOWN PENNA. PENNSYLVANIA

THE ATLAS MINERAL PRODUCTS CO. OF PA. — The House of Jointing Materials — MERTZTOWN, PA. EST. 1885

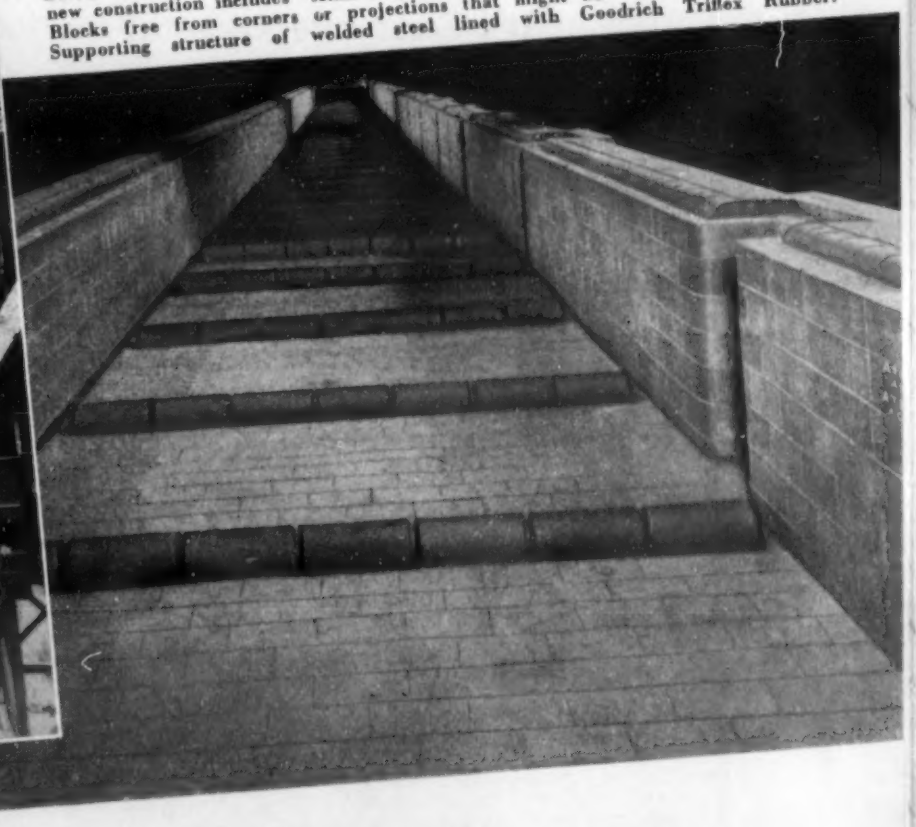
COMPLETE ACID-PROOF CONSTRUCTION SERVICE

Materials · Design · Construction

Acid-proof Units of Atlas Materials, Design and Construction—from small portable tanks to long lines of Continuous Picklers—are helping maintain uninterrupted production in America's largest mills.

Typical Atlas installation for the continuous pickling of steel. Ten tanks 60'x4'x4' and four tanks 25'x4'x4'. Steel shells lined with Goodrich Triflex Rubber and 8 inches of acid-proof brick jointed with Tegul-VITROBOND.

Below—Continuous pickling line of Atlas Dual Construction—165'x9'x3'. This new construction includes *Atlas Improved Expansion Joints and New Type Skid Blocks free from corners or projections that might be broken off in service. Supporting structure of welded steel lined with Goodrich Triflex Rubber.



ATLAS ACID-PROOF MATERIALS include:

PECIAL CEMENTS designed to withstand the attacks of any given type f corrosive and to meet high operating temperatures.

Tegul-VITROBOND—absorption less than 1%. Sets at once, regardless of temperature. Tank linings of *Tegul*-VITROBOND become ready for service immediately on completion; withstand temperatures to 200° F.

Carbo-VITROBOND—for hydrofluoric and nitric acids used in pickling stainless steel.

KOREZ—resin base cement—absorption less than 1%. Sets by chemical action. Inert to all acids with exception of nitric, chromic and hydrofluoric at temperatures up to 330° F.

Carbo-KOREZ—inert to hydrofluoric of any concentration and to acids listed for regular KOREZ. Withstands temperatures to 330° F.

ALKOR—Inert to all alkalies, grease, solvents and to non-oxidizing acids.

er special ATLAS Acid-proof Cements for Floors, Sewers, Drains, Flues, rks, Fume Ducts, etc., etc.

ACID-PROOF BRICK—inert to all acids except hydrofluoric.

ACID-PROOF CARBON BRICK—Resists hydrofluoric.

se Atlas brick have scored surfaces which secure maximum adhesion h jointing compound.

ATLAS DESIGN

proved its efficiency through years of service in the world's largest steel nts.

as Representatives are technical men, competent to discuss and advise upon your acid-ing problems. Address the one nearest you, or write our Engineering Division here at rtztown, Pennsylvania. Ask for our Technical Bulletin 2-A.
as Representatives are located at addresses given below:

ATLAS METHODS OF CONSTRUCTION

Atlas installations may be made under our supervision. Materials, design and construction methods from a single source means centering of responsibility and avoidance of errors that might prove costly. With Atlas Service you are assured right materials, correct design and expert construction methods, which also reduce your labor costs.

ATLAS DUAL CONSTRUCTION

. . . is used in the 165' tank pictured above. The lining next the corrosive bath combines Atlas Acid-proof Brick with KOREZ, chemically setting resin cement. Into the back course of the brick is poured *Tegul*-VITROBOND Improved sulphur cement. The heat of the solidifying *Tegul*-VITROBOND converts the KOREZ to its final set in a short time, and the tank is then ready for service. Atlas Dual Construction . . .

Is inert to hot acids and lime solutions. • Withstands operating temperatures to 250°F. • Unaffected by local overheating, as from faulty steam jets or heat generated by addition of concentrated acid. • Is immune to abrasion and turbulent liquids. • Resistant to oils. • Construction requires less labor.

Other notable improvements in acid-proof construction pioneered by Atlas include

*Rubber Expansion Joints in acid-proof brick sheathings.
**Tegul*-VITROBOND Plasticised sulphur base acid-proof cement Carbon Brick.
**Carbo*-VITROBOND tank linings for nitric and hydrofluoric acid mixtures, used in pickling stainless steel.
Acid-proof Brick with scored surfaces, insuring maximum bond.
Triple acid-proof membranes.

Tanks pictured also include *Atlas Interlocking Expansion Joints—developed in 1933. These make possible the construction of tanks of any desired length.

* *Fully protected by patents.*

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*DALLAS, Texas
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*DETROIT, Michigan
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*KANSAS CITY, Kansas
1913 Tauromee Ave.

NEW YORK CITY
280 Madison Ave.

PITTSBURGH, (10) Pa.
Old Boston Road

TORONTO, Ontario
McRae Engineering Equipment, Ltd.
11 King Street, West

The ATLAS MINERAL PRODUCTS Company of CALIFORNIA — Redwood City, California

DENVER, Colorado
1921 Blake Street

HONOLULU, Hawaii, U.S.A.
Lewers & Cooke, Ltd.

*LOS ANGELES, Calif.
817 Yale Street

*SEATTLE, Washington
1120 Eighth Avenue, South

mum tonnage that can be expected will be produced from a 3-grain system. The author's opinion is that if the moisture is maintained at much less than 3 grains, the furnace will have a tendency to hang and work on a higher pressure and will produce a poorer quality of iron. MS (1a)

Open Hearth Temperatures

STUDIES OF THE ACID OPEN HEARTH PROCESS ("Deb sura Martinprocessens förlopp") BO KALLING & NILS RUDBERG. *Jernkontorets Annaler*, Vol. 125, No. 7, 1941, pp. 283-326. Experimental.

Continuing earlier investigations (see METALS AND ALLOYS, Vol. 8, Dec. 1937, p. MA 726 R/4), the authors have investigated the effects of comparatively low temperatures on the operation of acid open hearth heats, and deoxidation and tapping conditions.

The results seem to prove that the product [C] [O] of carbon and oxygen contents in the steel approaches equilibrium with increasing temperature. The oxygen content of the bath may be raised considerably when the temperature is so low that the reduction of silicon is retarded.

Microscopic tests show that there are no appreciable amounts of inclusions in the steel prior to deoxidation, at least not in normal heats which are not too cool. This also seems to be the case in high-carbon heats, after deoxidation. In low carbon heats, on the other hand, where the oxygen content is comparatively high, a precipitation of silicate inclusions seems to take place as soon as silicon is added.

From a quality standpoint it seems to be of no importance whether the additions of silicon and manganese are made in the form of ferromanganese, ferrosilicon, or silicomanganese, or in which order the two elements are added. A momentary precipitation of silica or silicates naturally takes place when silicon or manganese is added, and the concentration is raised locally over a certain limit. However, the precipitated particles are dissolved immediately as the homogeneity of the steel bath is restored.

During the tapping into the ladle or the molds the steel is exposed to the air, causing a strong increase in the nitrogen content. It may seem strange that the oxygen content is not also raised at the same time. However, in high carbon steels the carbon is first oxidized by the air, while silicon and manganese are protected from oxidation. The main product of oxidation is therefore carbon monoxide, which escapes from the steel.

If, on the other hand, the carbon content is low, other alloying elements will be oxidized first, and form oxides which remain in the steel, causing a greater increase in the oxygen content during tapping.

Addition of lime to the slag bath was not found to cause any bad effects, neither on the operation nor on the analysis of the steel or the amount of inclusions contained. BHS (1a)

It's Good-bye to metal wastage—now!

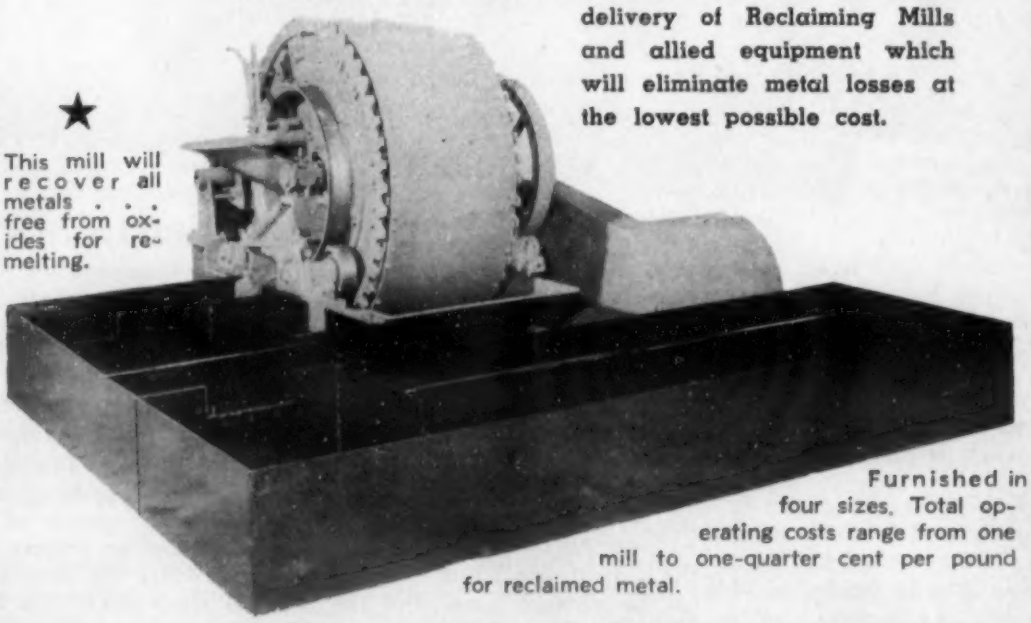
DEFENSE DEMANDS call for 100% Metal Production and Conservation

MILLS, foundries, casting shops can attain maximum results in both by eliminating the usual losses in skimmings and spills, amounting in copper alone to FIVE MILLION POUNDS per month, the usual 3% waste, which can be reclaimed in this country and thus increase production under specific allotments.

WE ARE DOING OUR PART

by concentrating our entire engineering service, experience and production facilities to an 'all out' effort to speed delivery of Reclaiming Mills and allied equipment which will eliminate metal losses at the lowest possible cost.

★ This mill will recover all metals . . . free from oxides for remelting.



Furnished in four sizes. Total operating costs range from one mill to one-quarter cent per pound for reclaimed metal.

WRITE or WIRE for Bulletin M1

Equip now! Use to the last ounce all your metal allotment for Defense and be prepared to meet post-war competition.

METAL RECLAIMING MILL

DREISBACH ENGINEERING CORPORATION

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New York, N. Y.

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Yonkers, N. Y.

1b. Non-Ferrous

Molding Sands for Magnesium

"MOLDING SANDS FOR MAGNESIUM ALLOYS." *Light Metals*, Vol. 111, Oct. 1941, pp. 206-208. Review.

Sand molds for magnesium alloy castings must be very well vented because of the low surface tension and low density of the metal. Ordinary sands and venting methods are not sufficient for producing satisfactory magnesium castings.

Also, an inhibitor of some type must be mixed with the sand to minimize the reaction of the water with the magnesium. Inhibitors may act in 3 ways: to form a protective atmosphere, to produce a protective skin on the surface of the metal, and to coat the grains of sand with fused, inactive salts. An example of the first class is sulphur, which is probably the best known inhibitor. Ammonium bifluoride, which is an inhibitor of the second class, forms a fluoride skin on the molten metal.

The difference in behavior of sulphur and ammonium bifluoride may be observed by etching with a 10% nitric acid solution. The acid readily attacks the casting made with sulphur-treated sand, while a casting made with the aid of ammonium bifluoride is resistant to etching. Boric acid, which is sometimes used, offers protection by coating the grains of sand, and hence isolating them from attack.

In cases of insufficient protection, blackened areas are seen, and areas of scab-like "oxide" mixed with grains of sand. There is evidence that the burning is not confined to the reaction between magnesium and moisture, but magnesium and silica apparently form magnesium silicide. The foundry sand should be analyzed daily for inhibitor content, as well as for the highly important property of permeability.

The use of a synthetic sand mixture is generally recommended rather than the mere adding of an inhibitor to a natural sand. The greater uniformity of permeability and clay bonding possible in synthetic mix-

A-26 HEAVY DUTY

Temp. Limits:—2600° F. on hot face.
Crushing Strength (cold)—409 lbs. per sq. in.
Weight, standard straight—2.80 lbs. each.

A-23 HEAVY DUTY

Temp. Limits—2300° F. on hot face.
Crushing Strength (cold)—491 lbs. per sq. in.
Weight, standard straight—2.75 lbs. each.

A-25 LIGHT DUTY

Temp. Limits—2500° F. on hot face.
Crushing Strength (cold)—325 lbs. per sq. in.
Weight, standard straight—2.35 lbs. each.

A-20 LIGHT DUTY

Temp. Limits—2000° F. on hot face.
Crushing Strength (cold)—227 lbs. per sq. in.
Weight, standard straight—1.90 lbs. each.

A-16 LIGHT DUTY

Temp. Limits—1600° F. on hot face.
Crushing strength (cold)—186 lbs. per sq. in.
Weight, standard straight—1.80 lbs. each.

27 Years' Experience

SAVING FUEL—CONTROLLING HEAT

LIGHTWEIGHT ARMSTRONG'S INSULATING FIRE BRICK have been improving furnace operation since 1914

TWENTY-SEVEN years ago, Armstrong introduced what was then a radically new type of furnace insulation—*lightweight* insulating brick. Today, *five* different types of LIGHTWEIGHT ARMSTRONG'S INSULATING FIRE BRICK are saving fuel, speeding production, and aiding accurate temperature control in furnaces throughout the country. These five brick, for temperatures from 1600° F. to 2600° F., embody the many improvements Armstrong has pioneered during 27 years of leadership in the field.

PERFORMANCE TESTED

All essential requirements for efficiency, i. e., low thermal conductivity, high physical strength (hot and cold), light weight, low shrinkage, and high resistance to spalling are met by the proper combination of characteristics in each Armstrong's Brick. Lasting satisfactory performance in the field, and rigid laboratory tests have proved that all five Armstrong's Brick are ideally suited to the service recommended.

MONEY-SAVING ADVANTAGES

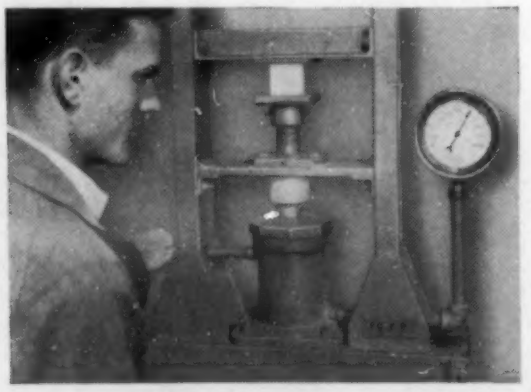
Armstrong's Brick arrive on the job in good condition. They are accurately sized so that they lay-up quicker, assure a heat-tight job, and increase construction strength. These lightweight brick have exceptionally low heat storage capacity which means they heat up quicker and cool off quicker. Batch type or intermittent furnaces heat and cool more quickly and with valuable fuel savings.

All Armstrong's Brick are available in special shapes to assist in unusual furnace constructions, or in standard sizes which may be notched, grooved, and shaped with a saw or rasp right on the job. Thus, there is no need to stock large inventories of unusual sizes and shapes for repair purposes.

ENGINEERING SERVICE

Qualified Armstrong engineers will be glad to assist you in the selection of proper insulating brick and cements and their application. For information about this service, and folders about Armstrong's Insulating Fire Brick and Cements, write today to Armstrong Cork Company, Building Materials Division, 982 Concord Street, Lancaster, Pa.

The unusually high spalling resistance of Armstrong's Brick is proved in this test which subjects panels of brick alternately to 2000° F. and 1400 c.f.m. of air at 70° F. 10 times in 10-minute cycles after a 24-hour pre-heat at recommended top service temperature.



Crushing strength tests prove that lightweight Armstrong's Insulating Fire Brick have exceptionally high load bearing characteristics. Heavy duty brick resist pressures up to 430 pounds per square inch—assurance that they will stand the gaff in your furnaces.

ARMSTRONG'S
INSULATING REFRACTORIES

tures ordinarily make the foundryman's job easier.

The base of the mixture is a washed silica sand of maximum silica content and fairly large grain size. To this bentonite, inhibitor, and the necessary amount of water is added. Most natural sands are not sufficiently permeable. The moisture content should be about 4-6%, with 3-5% bentonite, and an inhibitor content which varies considerably with type, and casting section.

A suitable mix has an A.F.A. permeability of 90-140. The following screen analysis is typical of a suitable silica sand base: on 44 mesh 23.5%; on 60, 53.2%; on 72, 11.5%; on 85, 6.9%; on 100, 1.9%; on 150, 1.3% and on 200, 0.5%.

Reconditioning equipment consists essentially of a sieve for removing "burnt lumps" and nails and for aerating, and a mixing mill for thorough mixing of the ingredients. Crushing should be avoided, as permeability will be decreased.

The amount of inhibitor used varies with the size of the section, thicker sections requiring higher percentages. In the case of sulphur, the variation may be between 2 and 10%. An excessive amount of sulphur results in a decrease of permeability. Boric acid is used in amounts of 0.5 to 5.0%, but ordinarily does not exceed 1%. Ammonium bifluoride may be used up to about 4%.

Aluminum molders will find the molding properties of such synthetic sands somewhat different from those of natural sands. For one thing, the high-permeability synthetic sands dry very rapidly, and in molding will feel dry. However, no difficulty in molding should be experienced. Permeability decreases with use, as the bond strength increases.

Similar sands are used for cores, but core sand may be even coarser than that used in molding. AUS (1b)

Zinc Alloy Slush and Permanent Mold Castings

"Fueling for Zinc Slush and Permanent Mold Casting." *Industrial Gas*, Vol. 20, Oct. 1941, pp. 12-13. Descriptive.

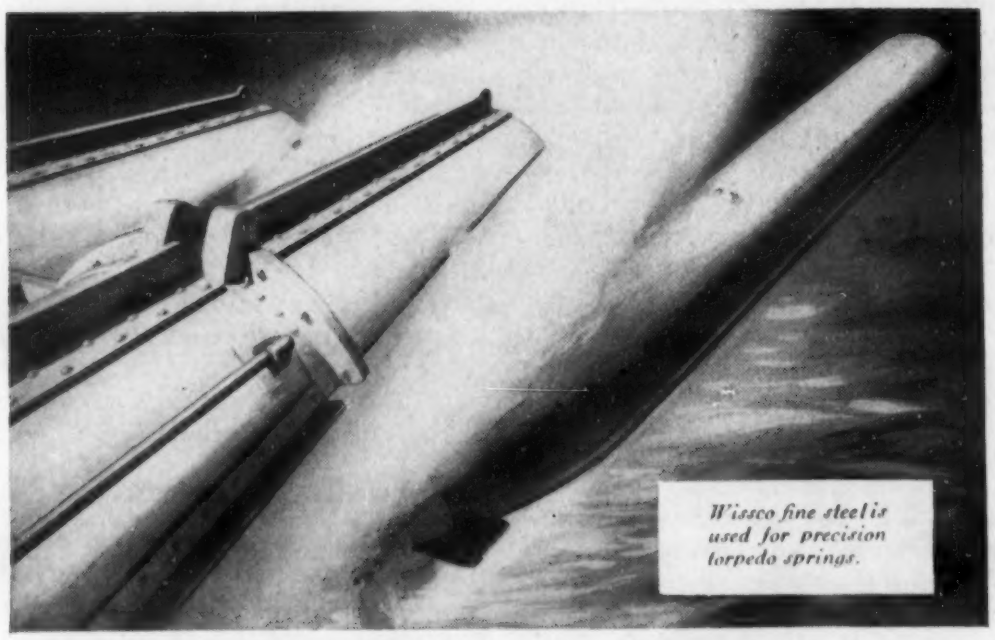
Slush casting has a definite place in production where (1) great strength, shock resistance or wearing qualities are not required; (2) ornamentation and detail on the casting is often complex; and (3) the number of units to be produced is large, but not large enough to justify the cost of expensive heat resistant dies for pressure casting. Permanent mold castings are used where thicknesses range from 1/32 in. to ¼ in.

The two most important factors involved in the production of good castings are the skill and experience of the mold makers and the casters, and exact time-temperature control of both the mold and the cast metal. The fueling of the melting pots is an important factor in obtaining fine time-temperature control.

Both slab and scrap are charged into melting pots to produce a high-purity zinc alloy containing 4% Al, minute amounts of copper and other additions to increase metal fluidity. Zinc alloy for permanent molding is cast at 900° F.; slushed zinc alloy is cast at from 600° to 700° F., depending upon the wall thickness and intricacy of the casting.

The bronze dies are internally recoated every half hour with a mixture of graphite and water. In slush castings, after the core metal has been slushed out, the casting is freed by striking the mold with a raw-hide hammer. Molds are used until wear affects their tolerances and fit together. The heat checking, which limits the life of die casting dies, is not prevalent in slush and permanent mold practice.

The castings are either finished by electroplating, electrochemical finishes or air-dry enamels. For many, no special finish is required. HRC (1b)



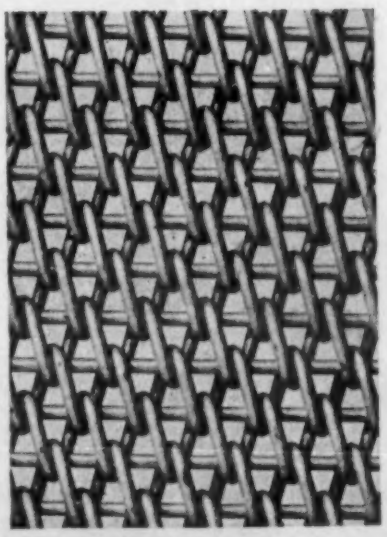
This Victory Torpedo Speaks about Conveyor Belts

Famed Wissco steels are being specified for such a wide variety of Victory "musts," that Wissco's blast furnaces and seven plants are going all-out, night and day.

You serve for Victory two ways, when you use high temperature belts that (1) last longer—so that they cut down belt repairs and replacements, and (2) thus help you maintain maximum production, without stoppages.

Wissco belts are made of alloy steels engineered in our own laboratories, and tailor-made to fit your temperature requirements.

Send for a copy of the free catalog handbook, "Wissco Conveyor Belts," which tells the story. Wickwire Spencer Steel Company, 500 Fifth Avenue, New York, N. Y. (Also Buffalo, Chicago, Worcester, and San Francisco)



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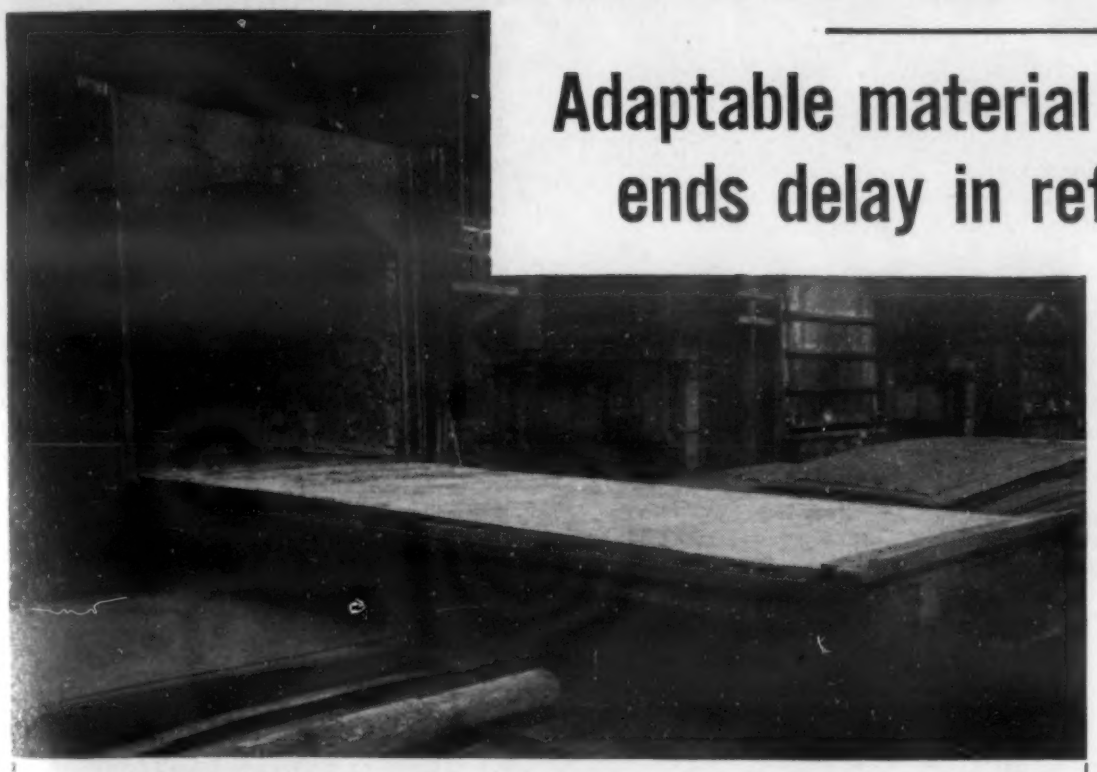
FURNACE BUILDERS SAVE TIME BY USING REFRACTORY CONCRETE

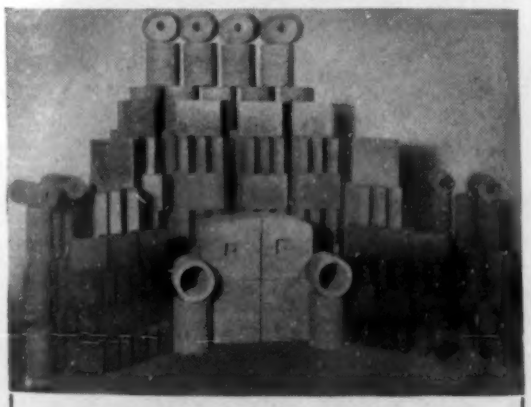
Adaptable material made with LUMNITE ends delay in refractory work . . .



● *An example of adaptability of Refractory Concrete is this annealing car top. It's a big top, 40 feet long by 12 feet wide. But, whether the top is small or large, Refractory Concrete can be made to fit. It's cast in place to suit the job.*

Save Money in 4 Ways with Refractory *Insulating* Concrete

By selecting the right aggregate you can have Refractory Concrete plus insulation. With LUMNITE as the



Another example of adaptability. *Refractory* Insulating *Concrete units good for 2000° F. Most of these shapes will go into laboratory furnaces to help American defense. The Universal Zonolite Insulation Company of Detroit is turning them out in quantity. Every one is made with LUMNITE!*

binder, a special, light-weight aggregate or insulating firebrick grog is used. Your savings result from:

1—Availability—no delay in construction.

2—Low initial cost of Refractory *Insulating* Concrete compared with other insulating refractories.

3—Adaptability—cast in place to fit the job.

4—Reduction of heat loss in operation.

Ready-to-use LUMNITE Insulating Castable Refractories are also available. As with other LUMNITE castables, they are shipped in dry form, mixed with water on the job and cast in place.

For Convenience, Use Castable Refractories Made with LUMNITE

Factory-prepared LUMNITE Castable Refractories are ready to use without the addition of anything except water. When mixed with water, they may be cast in place or molded into precast units in the same manner as all Refractory Concrete.

These ready-to-use LUMNITE Castable Refractories are accurately proportioned mixtures of LUMNITE and properly sized refractory materials. They can be obtained from refractories manufacturers and distributors—without delay.

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Refractory Concrete is made with LUMNITE and refractory aggregates. LUMNITE is sold by building supply dealers throughout the United States and in Canada.

The aggregates—refractory materials crushed and sized for making concrete—can be prepared in your plant or obtained from manufacturers and dealers. A number of light-weight aggregates for Refractory *Insulating* Concrete are also available at low cost.

Adaptability of Refractory Concrete saves time

Molded in place, formed to fit the skewback, arch, port or whatever complicated section you need, Refractory Concrete eliminates cutting, does away with special shapes, leaves no waste. It is formed to fit your job. You can even change your mind at the last minute, change thickness of wall or design of arch—without changing material requisitions.

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Find out about using Refractory Concrete to meet *your* requirements. Tell us what you need. Low temperature, high temperature, insulation? Write The Atlas LUMNITE Cement Company (United States Steel Corporation Subsidiary), Dept. M., Chrysler Building, New York City.

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Dry Forging Lubricants

"Dry Forging Lubricants." Arthur F. Macconochie (Univ. of Va.) *Steel*, Vol. 109, Aug. 18, 1941, p. 64. Practical.

The objectives sought in a lubricant applied to the punch of a forging-press include cooling of the punch, lubricating to ease the withdrawal, acting as a protective coat to lengthen punch life, and generating gas ahead of the punch to promote withdrawal.

In one method, a slightly roughened punch is used. Minute surface depressions trap the lubricant until stripping takes place. It may be supposed that each of these tiny pockets functions as a gas generator and that the lubricating effect is secured by a multitude of partially gaseous contacts under considerable pressure.

The punch is not given a high polish and is preferably made from steel containing tungsten. Another method, which either does not find favor or is not widely known in the U. S., is the use of a polished punch and a little powdered coal thrown in ahead of the punch to generate enough gas to help eject the punch and act as a lubricant.

The carbon film also helps to insulate the punch from the heat of the work. The use of carbon as an insulator is recommended highly by one shell manufacturer, who produces the initial coating on the punch by an aqueous solution of colloidal graphite. The coat is maintained by subsequent dippings in suspensions of colloidal graphite. For example, piercers are heated to 300° F. and dipped 7-10 times while hot into a 5% solution of "aquadag." The coat is maintained by lubricating the tools with a 3% concentrated "oildag" and 7% "dag," de-flocculated graphite suspended in a paraffin-base oil of about 350 sec. viscosity at 100° F. and 375°-400° F. flash-point.

Forging tools so treated have produced 14,000 75-mm. shells compared with 6,000-8,000 formerly obtainable. Still better results are obtained by nitriding the vanadium-steel piercer and applying the graphite treatment. MS (2)

Cadmium Plating

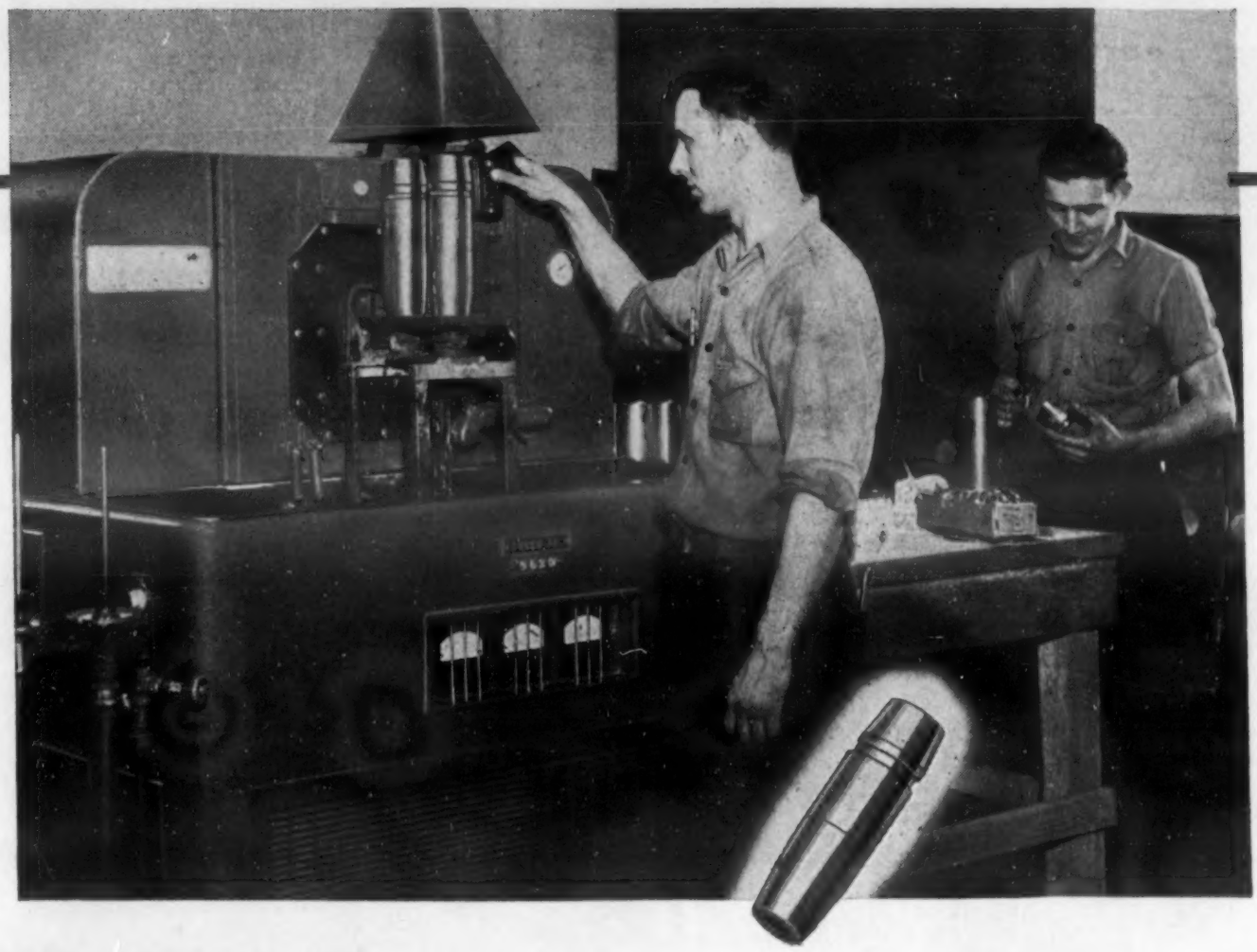
"Cadmium Plating." G. Soderberg (Udylite Corp.) & L. R. Westbrook (E. I. duPont de Nemours & Co., Inc.) *Trans. Electrochem. Soc.*, Vol. 80, 1941; Preprint No. 27, 13 pp. Review.

The main use of cadmium plating is to protect steel against corrosion. The important plating baths all contain cyanide. In electrowinning, an acid sulphate solution is used. The following is a typical composition for a cyanide bath: CdO, 23-29 gm./l.; NaCN, 86-131 gm./l.; addition agents.

Caustic soda is formed in the bath from the reaction of CdO with NaCN. The brighteners consist mainly of organic compounds, the use of which has in many cases been patented. Nickel and cobalt salts are often used in conjunction with the organic brighteners.

The cathode current density may vary from 1.6 to 4.3 amps./dm.^{2} depending on the cadmium content of the bath. The temperature of the bath is 68°-95° F. The cathode current efficiency varies between 85 and 98%.

Filtration of cadmium baths is desirable but is not as necessary as for copper and nickel baths, as pitted deposits are seldom encountered. Metallic impurities such as thallium, lead, antimony, arsenic, tin or



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● Armstrong Cork Company, Pittsburgh, Pa., is silver-soldering adapters to noses of 75 m. m. chemical shells at a rate of 25 seconds per shell per operator by TOCCO induction heating. Former methods would require at least 5 minutes per shell per operator . . . 12 times as long as induction heating!

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5. —to any depth—any area
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7. Retains ductility of core.
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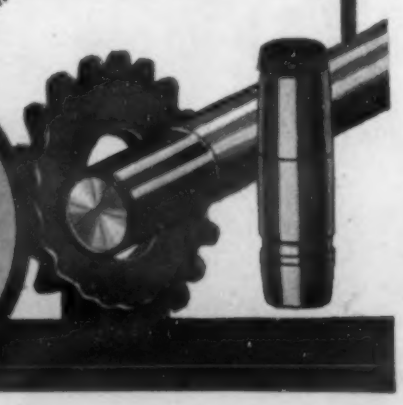

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World's Fastest, Most Accurate Heat Treating Process

silver cause discolored deposits. They can be precipitated with cadmium sponge or zinc dust, or by electrolysis at low current density.

The concentration of sodium carbonate should not be allowed to exceed 45 gm./l. in a bath containing 38 gm./l. of cadmium. Excess carbonate may be removed by the usual methods of freezing or by precipitation with calcium sulphate.

Soluble cast anodes, containing 99.9% Cd or insoluble anodes of steel are used, but if both types of anodes are used in one bath, individual rheostats must be used for each type because the polarization of the steel is higher than that of a dissolving cadmium anode. Anodes made from bearing scrap contain harmful amounts of silver, tin, nickel and lead, which produce rough deposits.

Rough or machined base metals are usually cadmium-plated without any polishing or buffing. The customary cleaning methods are used.

Cadmium coatings are bright dipped for 2 to 30 sec. to secure a brighter surface. Typical dips are: (1) CrO_3, 100 gm./l.; H_2SO_4, 2 gm./l.; (2) 30% H_2O_2, 7 parts by volume; H_2SO_4, 0.3 parts; water, 93 parts. CrO_3 dip passivates the cadmium surface. Cadmium brightened with a nitric acid dip tends to discolor on storage. Cadmium plating is usually not mechanically finished, but it may be buffed or scratch brushed.

Clear lacquers adhere well to cadmium, but good adherence of paints and pigmented lacquers is obtained only with a phosphate or chromate pre-treatment. Cadmium is not usually satisfactory as an undercoating for other metals. Thin silver coatings are absorbed by cadmium. Methods of testing cadmium coatings and of analyzing the bath are discussed. AB (2)

The ENGELHARD FLUALYZER provides a new, industry-proved method for testing burner efficiency of either oil or gas fired atmosphere type heat treating furnaces by determination of CO_2 percentage . . . The instrument is easy to use and fast, accurate determinations as to the oxidizing, neutral or reducing condition of the gases can be made by totally unskilled operators.

Compact and completely self-contained, the FLUALYZER is a light-weight, easily portable and extremely sensitive electrical indicator functioning on the thermal conductivity principle of gas analysis . . . A trial will convince you that this modern instrument has set new standards of convenience and reliability as a furnace atmosphere test unit.

Write for details and specific application data.

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Spot Welding Contact Resistance

"The Function of Contact Resistance in Spot Welding." R. F. Tylecote. *Trans. Inst. Welding, London,* Vol. 4, July 1941, pp. 154-165. Research report and review of literature.

When two pieces of metal are pressed into contact, the electrical resistance is greater than the sum of the resistances of the separate pieces. The additional resistance is called contact resistance.

In the case of steels, the contact resistance may be considerably increased by rolling-mill scale, grease, dirt, etc. In the aluminum alloys, it is chiefly caused by presence of an oxide film.

Two types of contact resistance are recognized, that between the electrodes and material, and that between the pieces of material welded. The first is further divided into electrode contact resistance, and interfacial contact resistance.

The electrode contact resistance in welding stainless steel decreases gradually with pressure, and at a critical pressure decreases rapidly due to puncturing of the film where metal-to-metal contact occurs. For welding dural sheet, the author considers that with high pressures the tabulated data show that contact resistance is more consistent, but that it may be desirable to start the weld with low pressure and high contact resistance, and then follow up with an increase in pressure.

It is found that the resistance of the oxide film bears no direct relation to the specific resistance of the material. Contact resistance appears to increase with temperature, until a critical point arises, at which the increase of resistance due to temperature rise in the adjacent layers and oxide film is not sufficient to balance new areas of contact formed, due to the crumpling of the original contacting spots.

It is also possible that the driving off of an adsorbed film (water vapor) could account for the drop in contact resistance with temperature. The author gives tabulated data and curves indicating the results obtained in his own research, and that reported in the literature. WB (2)

Acid Zinc Plating

"Acid Zinc Plating." Ernest H. Lyons, Jr. (Meaker Co.) *Trans. Electrochem. Soc.,* Vol. 80, 1941; Preprint No. 16, 12 pp. Review.

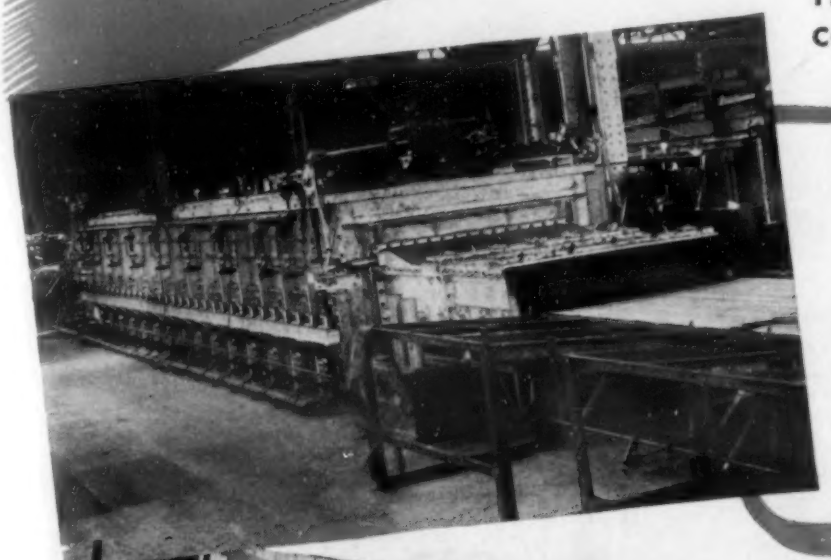
For protecting steel against corrosion, zinc coatings are more economical than coatings of other metals. Electroplated zinc and hot-dipped zinc afford about equal protection to steel.

Electroplating has the following advantages over hot-dipping: the absence of brittle alloy layers, superior uniformity on simple shapes, and the ease of control in applying coatings of a specified thickness. However, electroplated zinc will not bridge over seams and joints as does hot-dipped zinc.

A comparison between acid and cyanide zinc baths is as follows: The acid bath plates faster, has a lower operating cost,

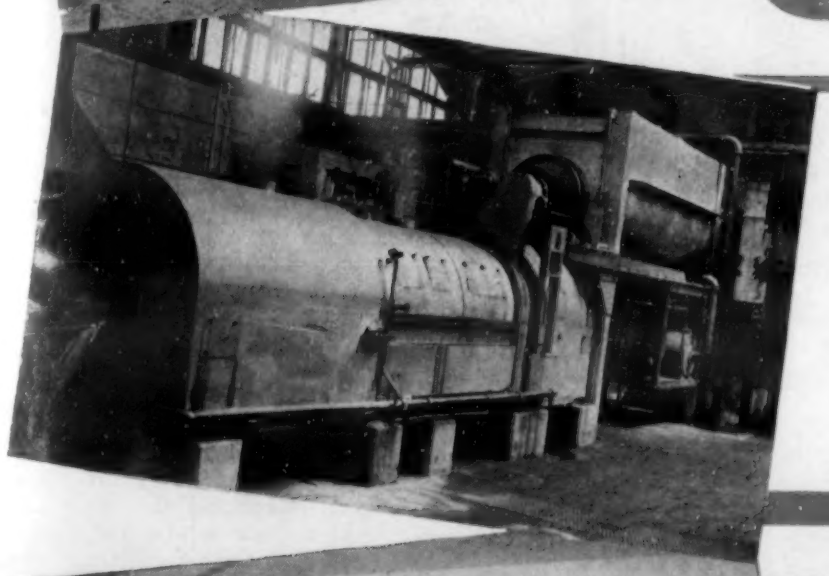
FURNACES THAT SAY IT WITH PRODUCTION

In the heat treatment of shells and other defense products, Rockwell Furnaces speak for themselves. Here are several of the many types that say it—convincingly—in terms of production.



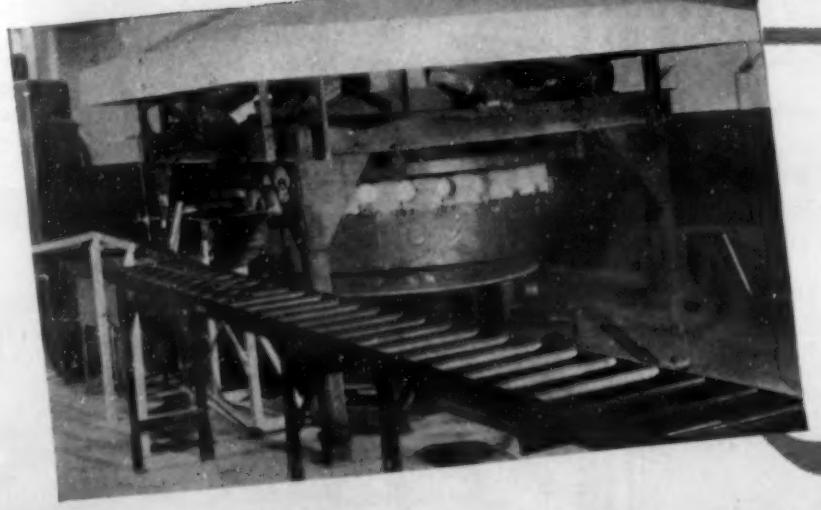
18,000 LBS. PER HOUR

This Gas Fired Roller Hearth Annealing Furnace handles cartridge brass slabs. Construction is unusually rugged — the rolls are extremely heavy, and the drive and all other parts are capable of this extreme production rate. Driven rolls carry the slabs from the charging table through preheating, heating and cooling sections, and on the discharge table to the dump mechanism.



3,000 LBS. PER HOUR

A Gas Fired Revolving Annealing Furnace (Retort Type) that is a complete unit for washing, annealing and pickling 50 caliber brass cartridge cups in a continuous, even stream. A great producer, it is also exceptionally economical from the standpoint of labor, fuel and in the use of acid.



70 SHELLS (4.5") PER HOUR

A Revolving Hearth Type Shell Nosing Furnace with openings around its outside circumference for receiving the shells. Heating is so controlled that no distortion occurs below the taper during the press operation. Charging and discharging from the same position requires only one operator — shells being sent to him on a conveyor. The absence of a water-cooled chill results in a great saving of fuel.

Because of standards already established, time-saving deliveries can be made on many types of Rockwell Furnaces. What is your heat treating problem?

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ROCKWELL SINCE 1888 BUILT

and can plate cast iron directly. The cyanide bath has superior throwing power and can be modified to give bright deposits.

A typical bath is: $ZnSO_4.7H_2O$, 410 g./l.; $AlCl_3.6H_2O$, 20 g./l.; Na_2SO_4, 75 g./l. A large number of addition agents have been tried, such as licorice, glucose, gelatin, B-naphthol, glycerine, etc. The current density in a still tank is 1-3 amps./dm.,^{2} but on moving wires, a current density of 200 amps./dm.^{2} is used. A temperature of 75°-85° F. is recommended; above 100° F., the deposits are darker. The pH is 3.5-4.5.

Zinc deposition is sensitive to metallic impurities in the bath, but most of these impurities separate out on the anodes during idle periods of the bath. The anodes used contain from 98.5 to 99.99% Zn. For special purposes insoluble anodes of a lead-silver or a silicon-iron alloy are used.

Standard methods of cleaning steel prior to plating are used, but special methods are used for wire, cold rolled strip and castings. Blistering of zinc coatings may result from inadequate cleaning, hydrogen absorption, or presence of inhibitors (from the pickling operation).

The thickness of coatings ordinarily used vary from 0.0001 to 0.001 in. The salt spray is not satisfactory for evaluating the quality of zinc coatings. Methods of determining the thickness are described. The Brinell hardness of electrodeposited zinc is 40-50. AB (2)

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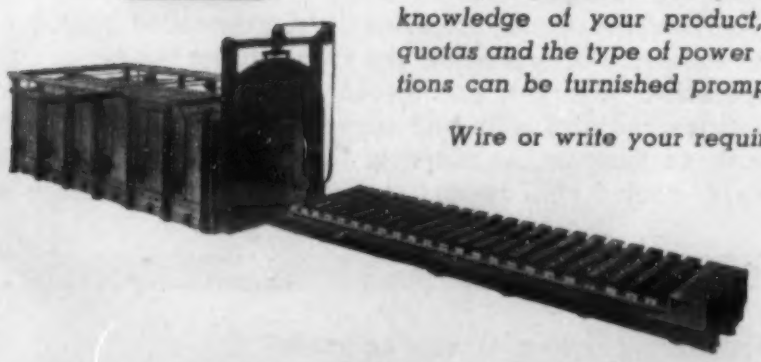
Wire or write your requirements.



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2a. Ferrous

Welding in Construction Work

"Adapting Structural Design and Construction Methods to Welding." LaMotte Grover (Air Reduction Sales Co.) *Paper, Am. Welding Soc.*, Oct. 1941 meeting. Review.

To realize the greatest economy from the use of welding for steel structures, the construction materials, the designing and detailing, the general facilities and methods of fabrication and erection, and the organization of personnel, must all be adapted to welded construction. Now that reliable procedures for welding have become quite well standardized, and shops have become organized to exercise proper engineering control over welding, results can be predicted with certainty, and costly confusion and delays have been eliminated.

Substantial improvements in electrodes, even since the adoption of the shielded arc, have done much to facilitate welding and to decrease its cost. The standardization in A.S.T.M.-A.W.S. Specification A233-40T has eliminated confusion. By choosing the most appropriate type of electrode for each application, costs have been reduced.

High-strength electrodes seldom are needed in welding high-strength structural steels, and their use is likely to make the welding more difficult in many cases. Silicon steel, as now manufactured, is not recommended for welded structures because of its high carbon and lack of uniformity in chemical composition. A tentative A.S.T.M. specification for Low-Alloy Structural Steel, now accepted by Committee A-1, provides for specifying grades of high strength steel suitable for welding.

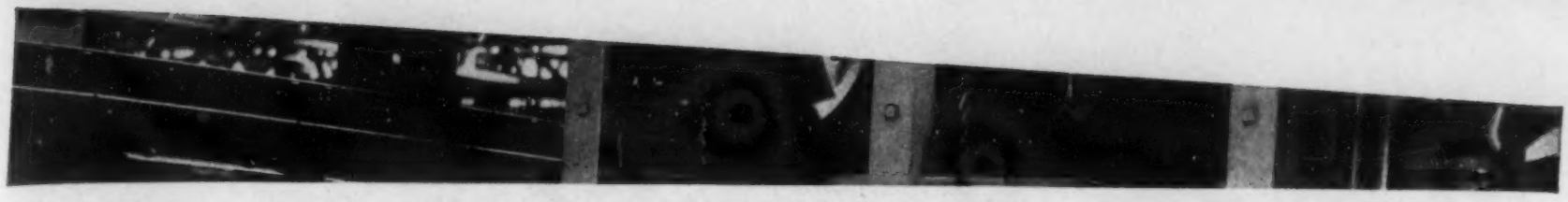
Most shops position their work for downhand welding (flat welds and horizontal fillets). Many, however, still do not use high-melting-rate electrodes for such work, to attain greater speed and efficiency, and the smoother welds of excellent physical properties that result from the use of such electrodes.

There is a continually increasing trend to a.c. welding in combination with larger diameter electrodes of this type for shop work. The most convenient sequence and direction of welding can be used without disturbance from magnetic flare, and distortion is largely eliminated through plastic deformation of the hot weld metal.

Designers are continually using more original thought and ingenuity in designing all-welded structure. It is still a common mistake, however, where some details of a structure are welded and others bolted or riveted, to specify a comparatively small amount of both welding and punching or riveting on the same piece, in such a way as to increase the cost of the shop work needlessly, because of extra handling of rather heavy pieces and other additional shop and field operations.

However, welded details such as cover-plates and stiffeners for rolled beams can be used to good advantage, even when field splices are riveted, although an all-welded design will improve the economy still further. When continuous or rigid frame construction is used to take fullest advantage of the natural ability of welding to form economical and effective rigid joints and connections, then the greatest opportunities for cost savings are presented.

Although some details developed for riveting happen to be suitable also for welding, the amount of cost that can be saved by welding is nearly always proportionate to the degree of special adaptation of details to welding. (2a)



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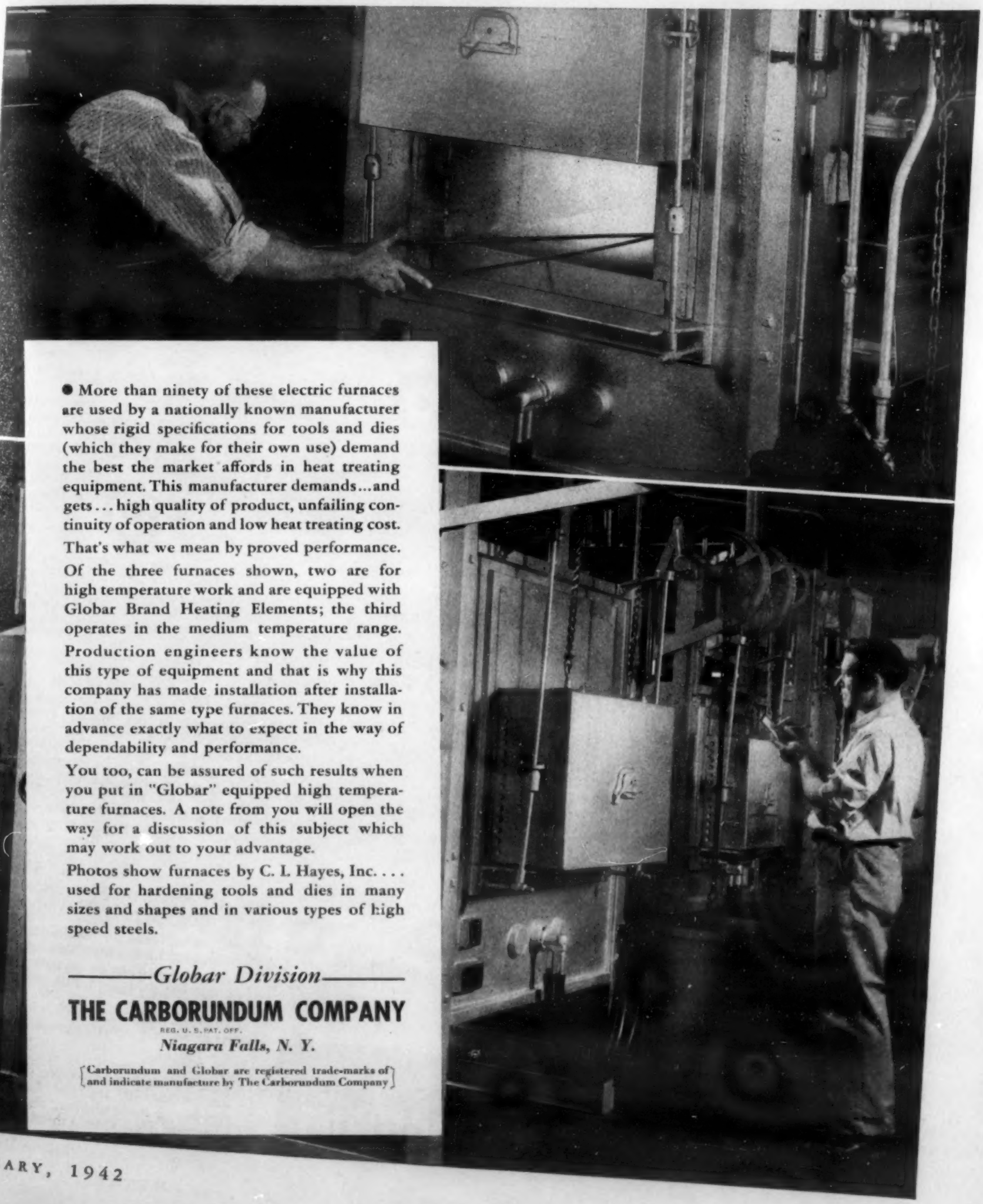

● More than ninety of these electric furnaces are used by a nationally known manufacturer whose rigid specifications for tools and dies (which they make for their own use) demand the best the market affords in heat treating equipment. This manufacturer demands...and gets... high quality of product, unfailing continuity of operation and low heat treating cost.

That's what we mean by proved performance.

Of the three furnaces shown, two are for high temperature work and are equipped with Globar Brand Heating Elements; the third operates in the medium temperature range.

Production engineers know the value of this type of equipment and that is why this company has made installation after installation of the same type furnaces. They know in advance exactly what to expect in the way of dependability and performance.

You too, can be assured of such results when you put in "Globar" equipped high temperature furnaces. A note from you will open the way for a discussion of this subject which may work out to your advantage.

Photos show furnaces by C. I. Hayes, Inc. . . . used for hardening tools and dies in many sizes and shapes and in various types of high speed steels.

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Electropolishing Stainless Steel

"Electropolishing Stainless Steel in Phosphoric-Sulfuric Acid Baths." Charles L. Faust & H. A. Pray (Battelle Mem. Inst.) *Proc. Am. Electroplaters' Soc.*, 1941, pp. 104-112. Descriptive.

The baths described contain sulphuric, phosphoric and chromic acids, and water. The chromic acid is not essential. Sulphuric acid by itself requires a current density above 2500 amps./ft.^{2} to produce polishing whereas phosphoric acid requires a low current density and a long period of treatment.

Several typical formulae are as follows: (proportions by wt.) (1) 15-20% H_2SO_4; 63-67% H_3PO_4; balance, H_2O. (2) 40% H_2SO_4; 44-48% H_3PO_4; balance, H_2O. (3) 60% H_2SO_4; 30% H_3PO_4; H_2O. Chromic acid may also be present. The conc. of water can vary only through a narrow range.

More uniform brilliance and more satisfactory operating conditions are obtained with baths having a small sulphuric/phosphoric ratio. The current density used for the No. 1 bath varies from 70 to 500 amps./ft.^{2} The baths containing a higher sulphuric/phosphoric ratio may require current densities up to 2000 amps./ft.^{2}

Temperatures used vary from 80° to 300° F. The higher the temperature, the higher is the current density required. Too high a temperature will result in a pebbly or even an etched surface. Surface analysis charts are given comparing electropolishing with mechanical polishing, and illustrate that the tops of irregularities are removed by the anodic treatment. Agitation of the work is beneficial as it prevents furrows and ridges in a surface.

Of the metal dissolved in the bath by the electropolishing, part is precipitated out as sulphate, and some is removed by dragout. The baths may contain 4.5% of metals without detriment. About 2500 ft.^{2} of metal can be electropolished in 100 gal. of bath before this concentration of metal is reached. Tanks, cathodes and heating coils may be constructed of lead. AB (2a)

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For temperatures up to 2400° F.— Standard Firecrete. Ideal for furnace doors, baffles, kilns and waste-heat flues, poured linings, some types of combustion chambers. No drying or firing shrinkage up to 2400° F. 110 lbs. required per cu. ft.

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For temperatures up to 3200° F.— J-M Chrome Castable. Designed particularly for use in forging and heat-treating furnace bottoms where it effectively resists the action of iron scale. Ideal also as a slag-resistant base for billets. 180 lbs. required per cu. ft.

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Flame-Processing

A Composite

One of the outstanding metallurgical engineering trends of recent years has been the extension of application of the "welding torch" to a variety of non-welding jobs, such as flame-hardening, flame-softening, flame-cutting, flame-scarfing, flame-cleaning, etc., and the list is still growing rapidly. With the new applications has come new knowledge about "flame metallurgy" and this, in turn, has fostered still other applications.

Flame-Hardening

The flow of practical guidance on flame-hardening continues from the pen of J. A. Magrath ("Oxyacetylene Flame-Hardening," *Am. Machinist,* Oct. 15, 1941, pp. 1036-1038; Nov. 12, 1941, pp. 1134-1136). Distortion in flame-hardening is generally less than in conventional hardening, since usually only a localized surface area is hardened. A distortion of 0.002-0.005 in./ft. occurs when sections under 2 in. thick are hardened; this distortion can be compensated for by pre-bending in the reverse direction or reduced by immersing the steel in circulating water during hardening.

If the section is thicker, the restraining effect of the cold core metal minimizes distortion. Distortion is also lowered by using the minimum heat possible and producing the minimum depth of penetration needed. In the case of gear teeth where both sides of a flat object are flame-hardened simultaneously, distortion is practically nil; it is seldom a factor in band or progressive spinning or in hardening small areas of large objects.

Normalizing, annealing or stress relieving will reduce distortion. Even a very-low-temperature stress relief, such as 7 hrs. at 300° F., reduced distortion 25-40%. Tempering is not always necessary after flame-hardening, since the treatment can be made self tempering by suitable control of heat input and quenching medium.

Flame-hardening operators should be acquainted with the principles of heat treatment and must be able to judge temperature by color. It should be remembered that the light of the flame makes the metal appear colder than its actual temperature. Normally, the flame should be neutral.

The distance between the work surface and the tip of the inner cone of the flame should be about ⅛ in. Dark streaks on the surface indicate overheating usually as a result of having the flame too close. The angle at which the flame strikes the surface is not too critical, but is generally about 90 deg.

If relatively thin objects are being hardened, the usual quenching procedure may not be adequate, so an auxiliary cooling jet in front of the flame may be required as well as a copper shield between the cooling jet and the flame. In progressive flame-hardening, there is always a narrow soft zone (about 20-40 points Brinell below the rest of the surface) where

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LITHCARB embodies the basic principles of the LITHCO process which chemically-neutralizes oxidizing gases. There are no atmosphere adjustments provided, and special skill of the operator is not required. Operation is absolutely foolproof.

The unretouched photo of the LITHCARB-urized parts, above, graphically illustrates why no sand blasting, polishing or cleaning is necessary. Write today for literature and data; see how economies and speed-ups can be effected in your plant every day of the year. There is no obligation, of course.

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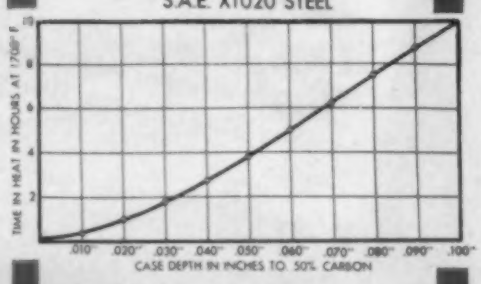
S.A.E. X1020 STEEL



This curve depicts the uniformity and speed of LITHCARB-urizing. The result is particularly outstanding because a case of .80 to .90% carbon is obtained by using a carburizing mixture of only one part propane to eight parts air.

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the flame overlaps; this zone can be decreased to about 1/16 in. by suitable use of shields. If the soft zone is detrimental, spinning methods should be used so that the entire object is heated before quenching.

Flame-Cutting Strong Steels

The amenability of several high-tensile steels to oxyacetylene cutting was studied by L. C. PERCIVAL ("Oxyacetylene Machine Cutting of Selected Types of High Tensile Structural Steels," *Trans. Inst. Welding, London,* Vol. 4, July, 1941, pp. 114-140). Eleven steels ½ and 1 in. thick were oxyacetylene machine-cut under controlled conditions, and tensile tests of the cut specimens were compared with results obtained on specimens prepared by machine tools. Cold bend tests were made on oxygen-cut specimens. Hardness tests were made on taper ground specimens of the oxygen-cut specimens, and micrographic surveys were made.

The steels tested were: Three carbon-manganese steels—(a) 0.18% C, 1½ Mn; (b) 0.22% C (0.30 max.), 1½ Mn; (c) 0.23% C, 1.4 Mn. Nickel steels—(d) 0.20% C, 2.4 Ni; (e) 0.31% C, 3.12 Ni. Other alloy steels—(g) 0.19% C, 0.82 Mn, 0.83 Cr, 0.32 Cu; (h) 0.09% C, 0.83 Cr, 0.28 Mn, 0.40 Cu, 0.46 Si, 0.15 P; (k) 0.11% C, 0.55-0.61 Mn, 0.78 Si, 0.45 Cr, 0.10 Zr; (1) 0.07% C, 0.60 Mn, 1.13 Cu, 1.31 Ni, 0.10 Mo; (n) 0.09% C, 2 Ni, 1 Cu; and (p) 0.20% C, 2 Ni, 1 Cu.

The figures for yield and ultimate stress do not differ markedly for the two methods of cutting; the range for flame cut values is a minimum of 900 lbs./in.² above the figures for the machined specimens. The figures on elongation are all less for the gas-cut specimens and range from 2.20% to 17.55% less elongation than similar machine-cut specimens.

Bend test results on flame-cut steels showed that steels (b), (c), (e) and (p) gave low-average bend angles in the ½-in. thickness; steel (g) had satisfactory bend angle in ½-in. thickness, but this was reduced to a low value for the 1-in. thickness. The steels (h), (k), (1) and (n) show a remarkable consistency and bend angle maxima for the series.

The average increase in hardness of the gas-cut specimen ranged from a maximum of 360 Vickers numbers for steel (c), with maximum hardness of 548 Vickers, to a minimum of 58 Vickers numbers for steel (1), with maximum hardness of 196 Vickers. The increase in hardness is compared with the average angle of bend, and an exactly inverse relation found to exist, *i.e.,* the greater the increase in hardness, the smaller the bend angle.

An extensive micrographic survey was made of the gas-cut edges. Generally, there was a slow-etching band at the surface, and below this band martensite was present together with unabsorbed ferrite as envelopes and persisting in its banded formation up to the cut face. Occasionally, the outer surfaces showed areas having the structure of white cast iron.

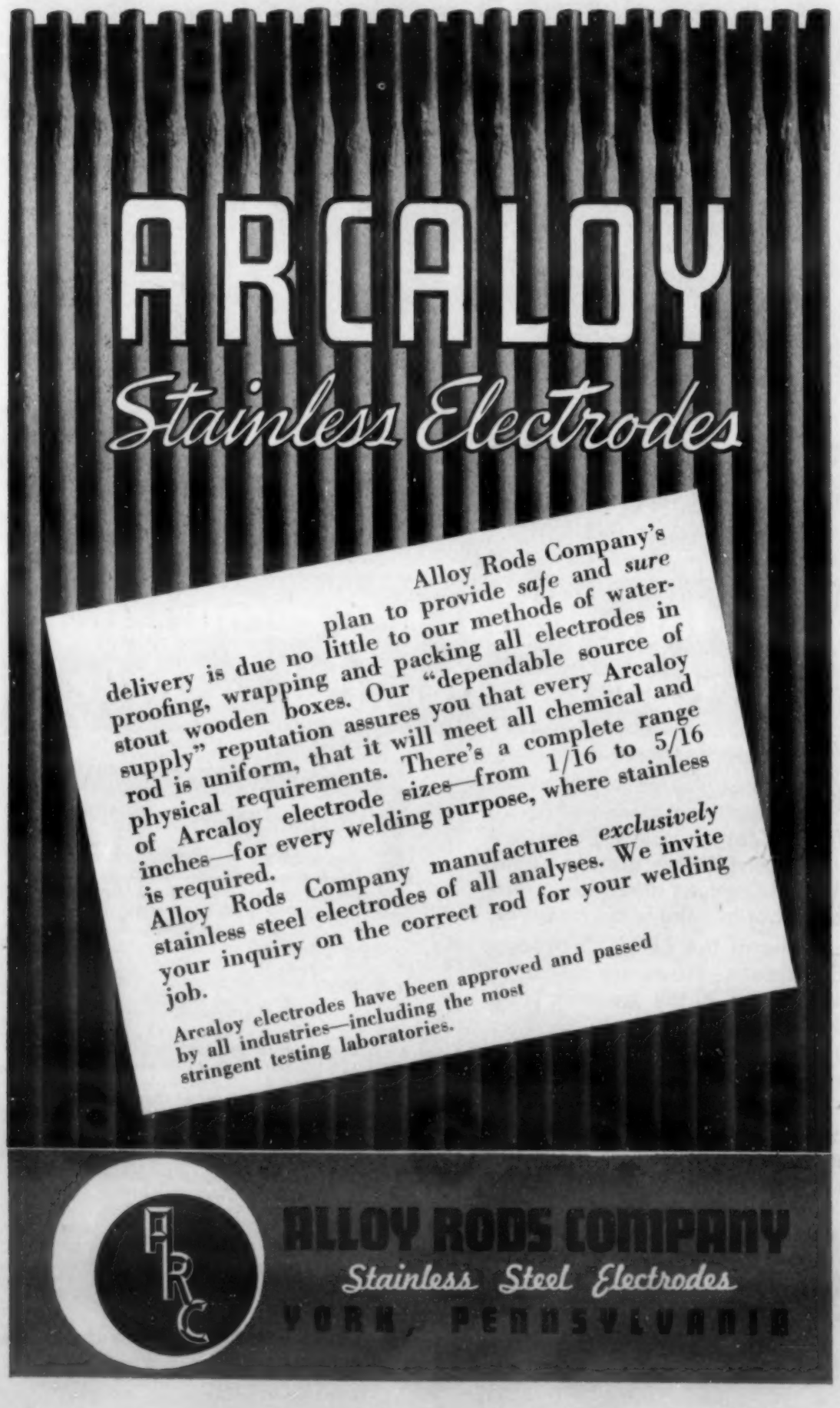
In steels (c), (e), (g) and (p), there was an abrupt line of demarcation between the heat-affected and unaltered zones. The steels (h), (k), (1) and (n) did not show martensite present in the cut surface, the structures ranging from sorbite to troosto-sorbite, which in part explains the large bend angles obtained for this group. However, these steels along with the others contained the thin band of slow-etching material at the outer edge, which has not been identified.

Welding tests performed on the gas-cut edges indicated that all of the heat-affected zone would be removed by welding, and it is the author's opinion that as long as cracking does not occur in gas cutting, the steel may be welded at the cut edge, irrespective of whatever microstructure and hardness the cut edge may possess. Pre-heating is recommended for most of the high tensile steels, in order to keep hardness within safe limits in the absence of cracking.

Flame Pre-Heating and Stress Relief

The application of arc-welding to high temperature (950° F.) and high pressure (over 1500 lbs./in.²) pipe for steam lines required suitable means of pre-heating the pipe and stress relieving the welding structure. P. T. ONDERDONK ("Flame Pre-Heating and Stress Relieving Arc-Welded High Pressure Pipe Lines," *Paper, Am. Welding Soc.,* Oct., 1941 meeting) points out also that the introduction of alloy steel and the heavy wall thicknesses needed for the large size pipe to carry the volumes of steam and water required by topping turbine installations of 50,000-60,000 kw. capacity made it desirable to use such a means.

The function of the pre-heat is to minimize shrinkage during the welding operation and preclude development of internal stresses high enough to produce cracks either in the weld metal or parent metal adjacent to the weld. The stress relieving operation is a continuation of this same function by relieving such internal stresses in the completed weld sufficiently to prevent failure when additional stresses are imposed by external loads in service.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REDUCED STRAIGHTENING! In Chicago, the new Lindberg heating principle cut straightening operations on worm gears from 95% requiring straightening to less than 2%.

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PROVED IN 97 INSTALLATIONS . . . It's brand new, this Lindberg development . . . but, like all previous Lindberg developments, it's been blasting away old heating theories . . . not in one installation, not two, not ten, not fifty but in 97 *installations from coast to coast* made during the past year.

Like the Cyclone Tempering Furnace that preceded it 7 years ago . . . . like Tubulaire Heating Elements 5 years ago . . . . like Hydryzing at the '38 Metal Show in Detroit . . . this new Lindberg development has gone through the required Lindberg probationary period of 1 year under heavy, 24-hour a day production conditions. From the very first day of operation it has completely upset old heating theories.

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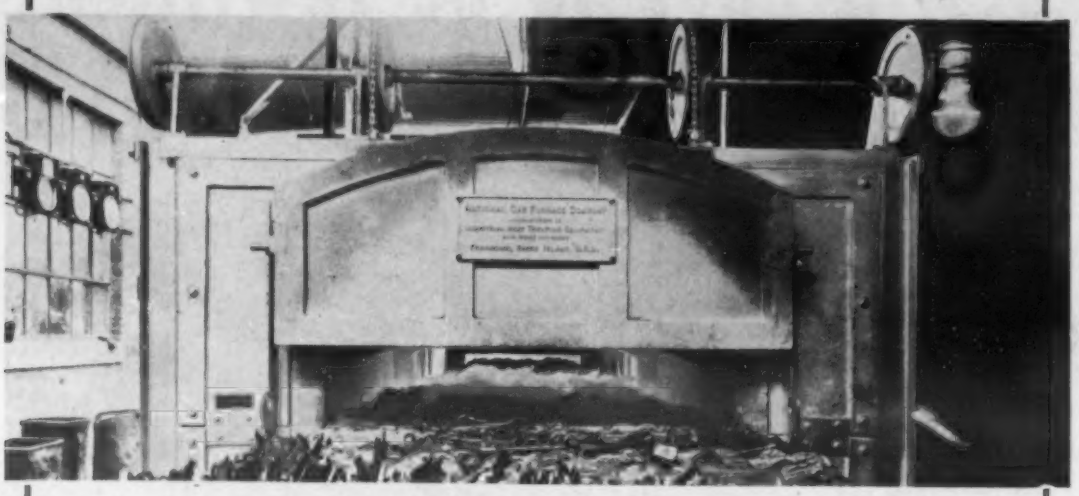

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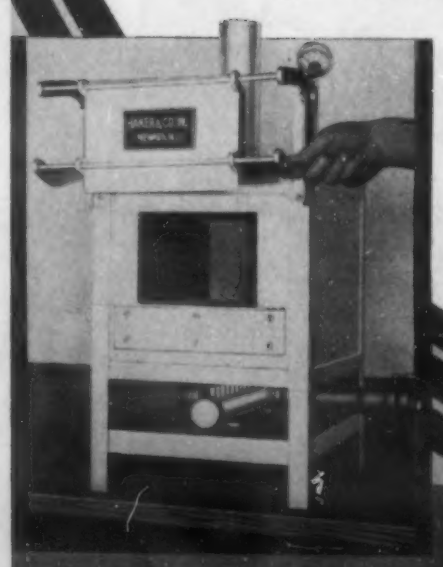

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Some of the methods developed for this purpose are applicable to shop practice only and others may be used for either shop or field work. Electric resistance and induction methods are popular with some engineers. The flame methods usually used are based on utilizing some of the more common fluid fuels such as fuel, oil, kerosene, illuminating gas, and oxyacetylene in a temporary or portable brick-type enclosure incorporating a suitable torch arrangement or in a multi-jet, ring-type burner.

As a result of changing field erection requirements, a demand arose for supplementing or replacing the electric methods previously employed with an improved flame method adapted primarily to field use. A study of available furnaces, burners, and fuels led to the development of a very satisfactory method employing propane.

A portable furnace to accommodate heating torches suitable for the use of propane was designed to permit readily mounting it for use on a pipe-to-pipe or pipe-to-fitting weld. The economic and physical factors favoring the selection of propane gas as fuel appear to be many, and the experience obtained in actual field application of this method show it to have considerable practical promise. X (2a)

Nitriding with Urea

"Urea Process for Nitriding Steels." R. P. Dunn, W. B. F. Mackay & R. L. Dowdell. *Am. Soc. Metals*, Preprint No. 26, Oct. 1941 meeting, 16 pp. Investigation.

A new nitriding process using synthetic urea is described in which Nitralloy G, S.A.E. X1314 and S.A.E. 1020 steels were successfully nitrided in a closed container using various proportions of urea with different nitriding times, temperatures and pressures.

Urea was selected as the nitrogen source because it was known to evolve ammonia upon heating, was cheap and was easy to handle and store. Its quoted price in large lots is about 4¼c/lb.

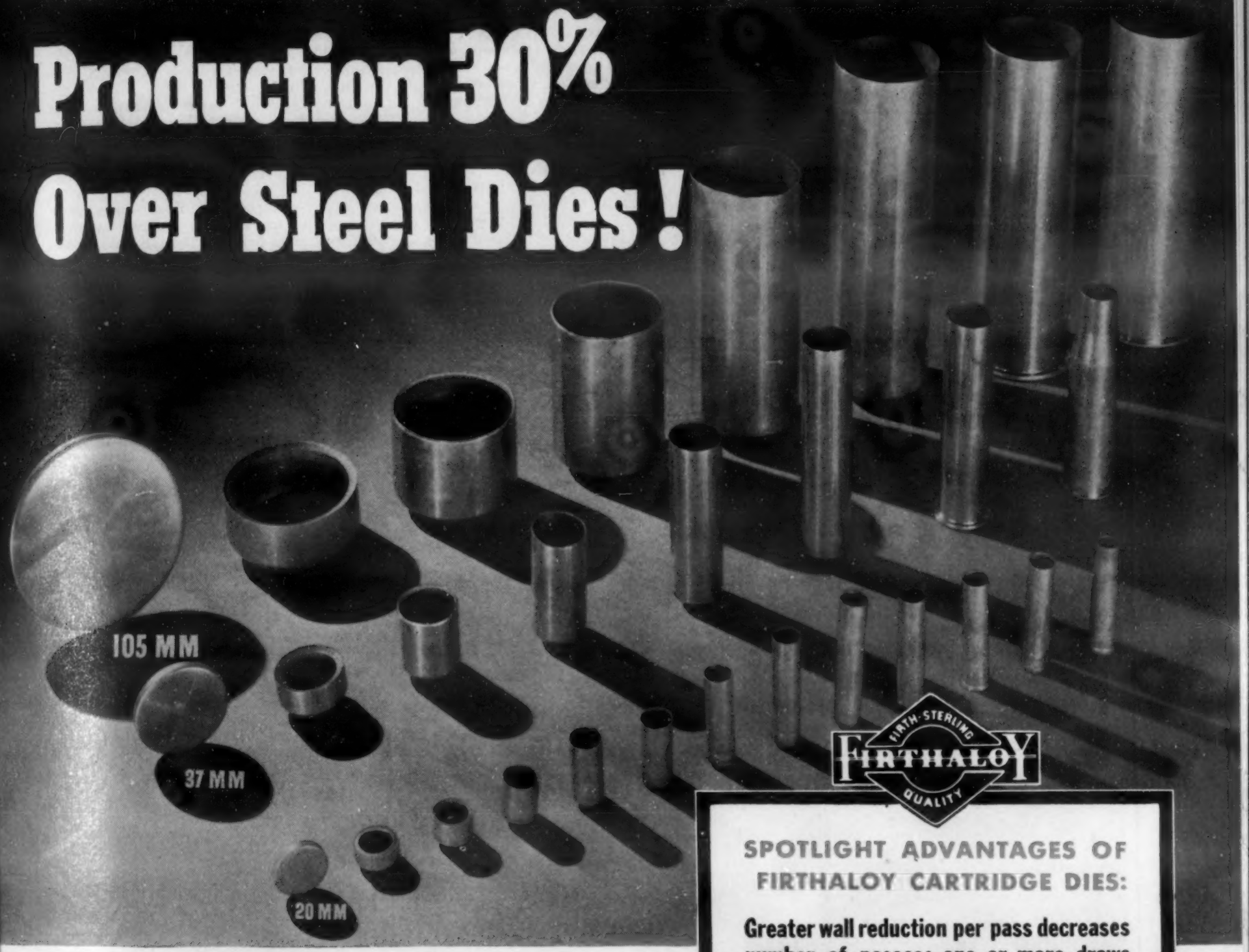
Commercial nitriding furnaces use a continuous flow of anhydrous ammonia. In this investigation, a satisfactory working set-up comprised a vitreous-silica tube furnace in which the specimens were placed, the ammonia being supplied to them from an external generator. The urea was placed in the external generator and slowly heated to the temperature of ammonia evolution (about 270° F.) but no higher, so that the rate of evolution could be easily controlled by regulating the flame.

Simultaneously, the tube furnace at the nitriding temperature of 950° F. was loaded with specimens and purged and the whole system regulated to optimum conditions of 270° F. generator temperature with a flow of 10 cc./min. Every 12 hrs. the generator was re-charged with 60 gm. of urea.

Both the S.A.E. steels showed only slight nitridability up to a temperature of about 1050° F. Above that temperature the surface hardness of the case increased very rapidly with rising temperature, up to a maximum of about 1200° F. Vickers hardnesses of the 1020 and X1314 steels nitrided at this temperature were 600 and 475, respectively.

The Nitralloy steel showed a maximum hardness at about 950° F. Above that temperature the hardness fell off and case depth increased. The case hardness gradient curves showed an average case depth after 20 hrs. of about 0.005-0.006 in., with

FIRTHALOY* Boosts Shell Case Production 30% Over Steel Dies!



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FIRTHALOY solid or sectional Carbide Dies *definitely increase shell case production* 30% *to* 35%! For this vital manufacturing need FIRTHALOY Cupping and Drawing Dies have proved their productive superiority on cases from 20 mm. to 105 mm. diameter. The advantages of FIRTHALOY dies apply equally to small arms cartridge cases . . . for drawing, loading, pointing, tapering, heading and other requirements.

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0.028 as the maximum depth for the Nitralloy G steel. The hardness gradient was quite steep for all of the samples.

The decomposition of urea at high temperatures produced 2 pressure maximums, the first of which (at about 480° F.) was due to the ammonia evolution, but the cause of the second (at about 800° F.) was unknown (unless it was the decomposition of a white deposit that formed in the cool pipe sections).

A Vickers hardness of 1124 was obtained with a Nitralloy G sample after 70 hrs., using the urea process. With suitable adaptation, therefore, the process may have distinct practical possibilities, especially considering the low cost of commercially pure urea. FPP (2a)

Hot-Dip Galvanizing

"Cause of Gray Sheets in Hot-Dip Galvanizing." Wallace G. Imhoff. *Blast Furnace & Steel Plant*, Vol. 29, Nov. 1941, pp. 1124-1126, 1148-1149. Practical.

The basic cause of gray sheets in galvanizing is rough surface of the steel base, resulting from an oxidized condition of the steel or from over-pickling. An oxidized steel base has relatively little or no metallic skin on its surface. Pickling makes the surface porous and permits the retention of hydrogen in the pores.

Similar conditions prevail with wrought-iron, which is made by a process which is essentially oxidizing. The metal not only tends to be oxidized, but also contains particles of iron silicate.

The zinc coating generally adheres very poorly to an oxidized base metal. Over-pickling removes the metallic skin and cuts deeply into the grain structure of the steel, producing a very rough surface. MS (2a)

Pressure-Welding Railroad Rails

"Pressure-Welding of Railroad Rails." L. Adams (Oxweld Railroad Service Co.) *Paper, Am. Welding Soc.*, Oct. 1941 meeting. Descriptive.

Oxyacetylene pressure-welding is a means of joining metals using heat and pressure. The joining takes place at a temperature below the melting point and when the metal is, metallurgically speaking, in the "solid state."

Oxyacetylene pressure welding has been found highly efficient for the joining of parts having a uniform cross section. Its widest use to date has been in the joining of rails for railroad use.

Pressure welding of rails consists of bringing the properly prepared ends of a rail together in a suitable machine, clamping them in accurate alignment, compressing them together end-to-end, while a series of oxyacetylene flames are applied completely around the rail ends at the point of juncture. When the metal reaches the plastic state, as shown by time and compression indications, the weld is finished. The excess metal at the weld, which has become upset during the welding process, is then removed and the weld zone is reheated to above the critical temperature in a normalizing operation which refines the grain.

Approximately 20 min. is required for the making of one weld or an average of about 25 welds in an 8-hr. working day. The equipment needed for this work is compact and simple and the men who operate the unit (with the exception of supervision) can be unskilled in welding operations, thus involving a minimum of tie-up of railroad facilities or delays for lack of skilled labor.

At the Univ. of Illinois, pressure-welded rails stood up well under metallographic and mechanical tests, including tensile, ductility, endurance-limit, reduction-of-area, tension-impact, bend, drop and rolling-load tests.

Pressure-welded rails have been used successfully in tunnels, through station platforms, over bridges, through road crossings, and paved streets, and other places where the rail is either covered or difficult to get to for maintenance of joints. It has also been used considerably for open track. Rail joined by this method has been laid in locations in the Northern states and as far south as the Arizona deserts, so that it has received the extremes of weather conditions without adverse effect. (2a)

Molybdenum High Speed Steel Tools

"Molybdenum High Speed Steels." J. P. Gill & Robert S. Rose. *Iron Age*, Vol. 148, Sept. 25, 1941, pp. 33-35. Practical.

The greatest difficulty with molybdenum high speed steel was its somewhat greater propensity to decarburization. Changes in manufacture, new developments in heat treating and chemical modifications have all been aimed at eliminating loss of surface carbon during treatment.

In the manufacture of the steel, the ingots are coated with borax or copper paint. The chemical composition has been modified by replacing small amounts of carbon with boron and by the addition of copper. All molybdenum steels can be heat treated without decarburization by the use of borax, by appropriate salt baths, or by treating in furnaces producing 20% or more of carbon monoxide.

X-ray diffraction analysis shows that when molybdenum is added to high speed steel, it replaced the tungsten atom in the double carbide. X-ray patterns of tempered specimens of 18-4-1 tungsten type, TM-2 (5-6 W, 4-5 Mo, 4.5 Cr, 4 V) and TM-3 (8 Mo, 4.5 Cr, 4 V) show 3 phases: retained austenite, primary martensite and the double carbide. The double carbide has the same parameter in all 3 types.

Substantial replacement of molybdenum with tungsten increases the stability of the retained austenite. For complete austenitic transformation in 2 hrs., a temperature of 1020° F. is needed with TM-3 and 1080° F. with TM-2.

Recently the standard high speed types have been modified with higher carbon and vanadium contents. This trend reached its maximum to date in type TM-2 and results in abrasion resistance several times that of 0.70% carbon 18-4-1.

Recent modifications in molybdenum high speed steel composition have followed the lines of good logic—as, for example, in the so-called 5-4 type. When the molybdenum content is reduced to under about 5.5% and replaced with between 5 and 6% tungsten, the propensity toward decarburization is almost eliminated. Such steels can be heat treated even in "obsolete" gas and oil-fired furnaces without atmospheric control.

Tungsten-molybdenum and molybdenum

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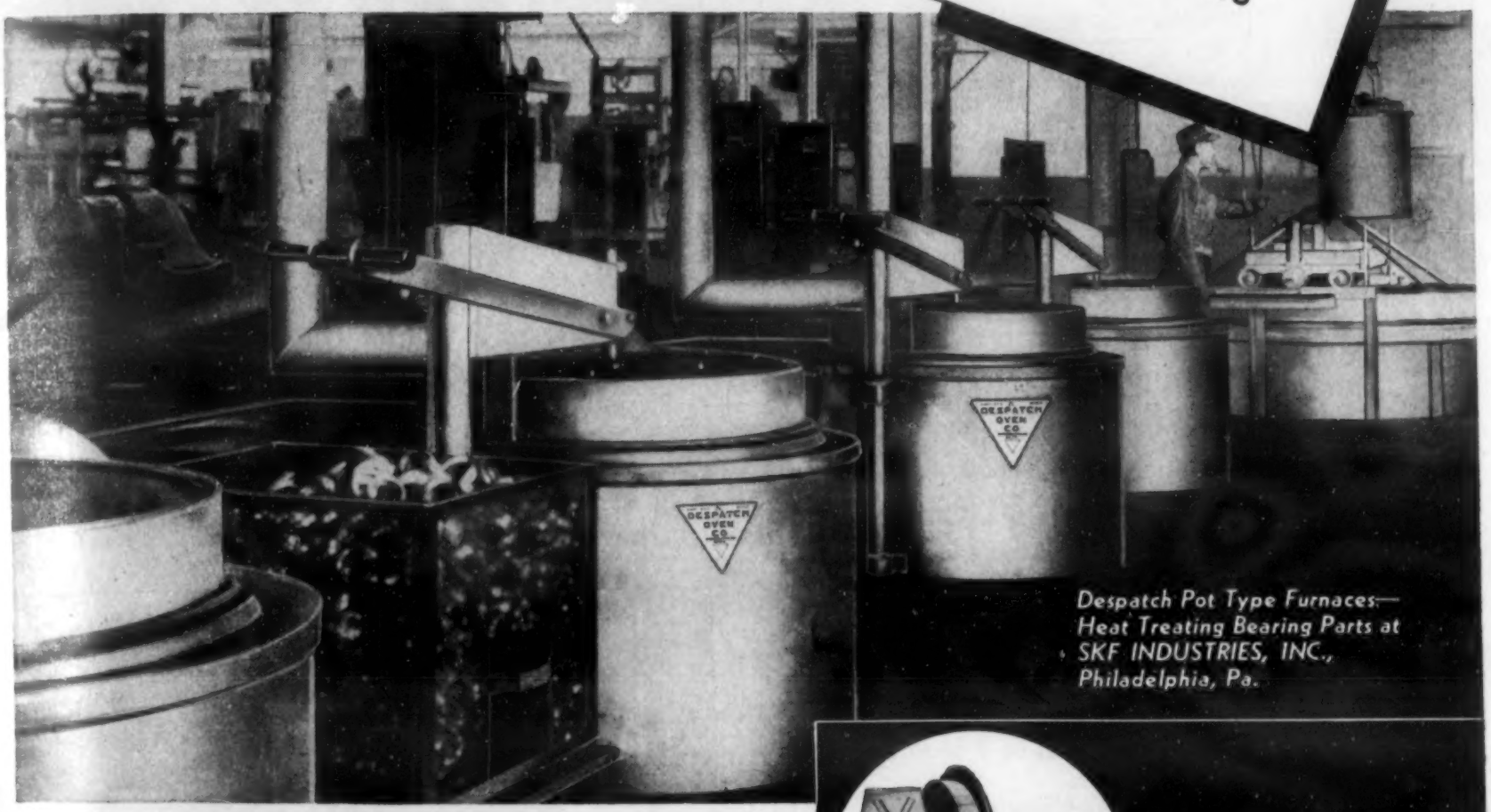

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All metal industries, whether making delicate watch springs or huge multi-ton castings, report remarkably improved heat treating results from Despatch Convection Type Furnaces.

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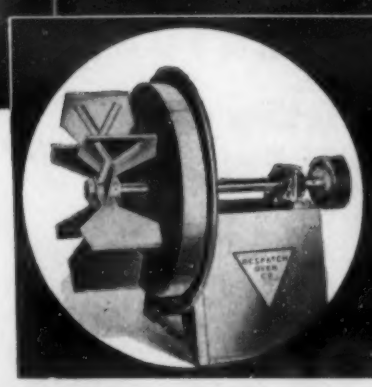
Despatch Furnaces are reported to have cut processing time as much as 50%—also to have reduced operating costs by 80%.

Despatch furnaces are recommended to improve heat treatment of low carbon steels . . high carbon steels . . alloy steel parts . . aluminum alloys . . magnesium alloys . . brass, and other non-ferrous castings, forgings, sheets and shapes.



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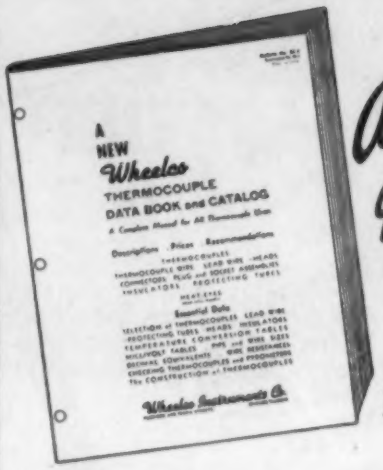

Any questions about thermocouples?

DO YOU KNOW—

—how to make a thermocouple? *See Page 21**

—where bare thermocouples can, or cannot, be used? *See Page 4**

—the applications for radiation type thermocouples—Heat Eyes? *See Page 12**

—what type of protecting tube to use for your application? *See Page 14**

—how to select lead wire? *See Page 12**

—how to check thermocouples and pyrometers *See Page 22**

* The above page numbers are from the New Wheelco Thermocouple Data Book and Catalog. Other valuable information, such as temperature conversion, tables, pipe and wire sizes, wire resistance, millivolt tables, decimal equivalents, etc., is included in this book.

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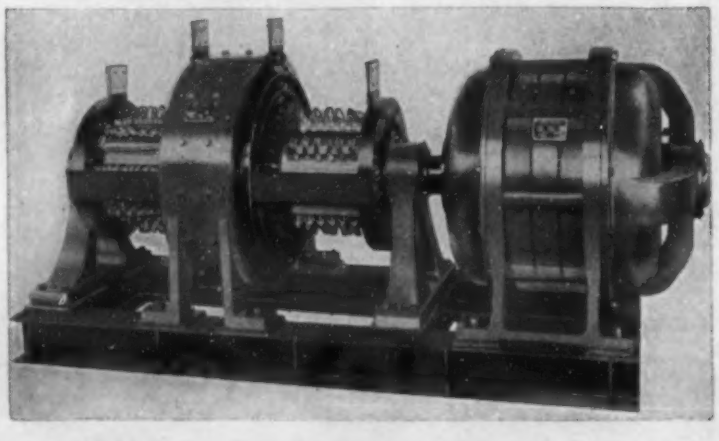

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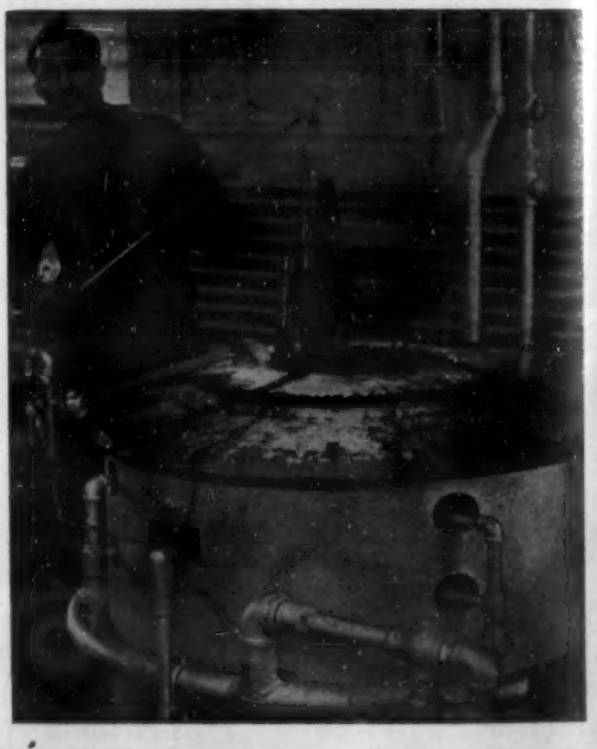

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high speed steels can be used for almost all types of cutting tools. One of the requirements of high speed steels is red hardness. The hot hardness of the type TM-1 steel (5-6 W, 3.5-5.5 Mo, 4 Cr, 1.4-1.75 V) is greater than the other molybdenum types. This is probably due to its appreciable tungsten content together with high vanadium. VSP (2a)

Heat Treating Pump Parts

"Heat Treating Parts for Deep Oil Well Pumps." C. O. Herb. *Machinery, N. Y.*, Vol. 48, Oct. 1941, pp. 109-116. Review of practice at Axelson Mfg. Co.

The cast-iron liners are stress-relieved at 1000° F. before any machining operations are carried out. Liners (made from a cast nickel-chromium-molybdenum iron—analysis not given) are rough-machined, then hardened by oil quenching from 1600° F. (hardness, Rockwell C 53-56) followed by tempering for 2 hrs. at 800° F. (hardness, Rockwell C 40-45). Seamless steel tubing liners are also normalized after rough machining, then finish-machined, carburized, hardened and tempered.

Plungers of S.A.E. 4615 steel tubing are carburized on the outside, machined, oil-quenched from 1450° F., and tempered for 2 hrs. at 350° F. (hardness, Rockwell C 60-65). This pack carburizing is carried out in long tubes of centrifugally cast heat-resisting steel.

Valve seats are made of stainless—either high-carbon high-chromium or low-carbon high-chromium medium-nickel (analyses not given). After machining, these valve seats are oil-quenched from 1775°-1875° F. with the exact temperature depending upon the analysis (hardness, Rockwell C 40-60, also depending upon analysis) and tempered at 350°-700° F. Stainless steel balls for use with the valve seats are subjected to the same heat treatment.

Sucker rod couplings are made of a nickel-molybdenum carburizing steel, which is pack carburized in boxes of cast heat resisting steel or welded Inconel. Samples are checked to determine the depth of carburization, which should be about 1/16 in. The couplings are then rough-machined, oil-quenched from 1480° F. and tempered. Steel tubing of S.A.E. 1045 is externally flame hardened, then tempered at 350° F. JZB (2a)

Machining Shell with Carbide Tools

"Machining Shell with Carbide Tools." M. F. Judkins (Firth-Sterling Steel Co.) *Mechanical Engineering*, Vol. 63, Dec. 1941, pp. 859-860, 869. Descriptive.

The problem of maximum shell production with available facilities is largely answered in the productivity of sintered carbide-tipped tools. It is, therefore, necessary to realize the maximum usefulness from these tools.

Usually, when carbide tools are used for the first time in machining shell, tool breakage is common in the early stages. Careful planning and careful checking preceding manufacture can eliminate a large portion of this breakage. Overhang of tool-slides at or near the end of the stroke may cause deflection sufficient to chip the cutting tool. The volume and method of application of the cutting oil should be carefully observed so that a floor of cutting

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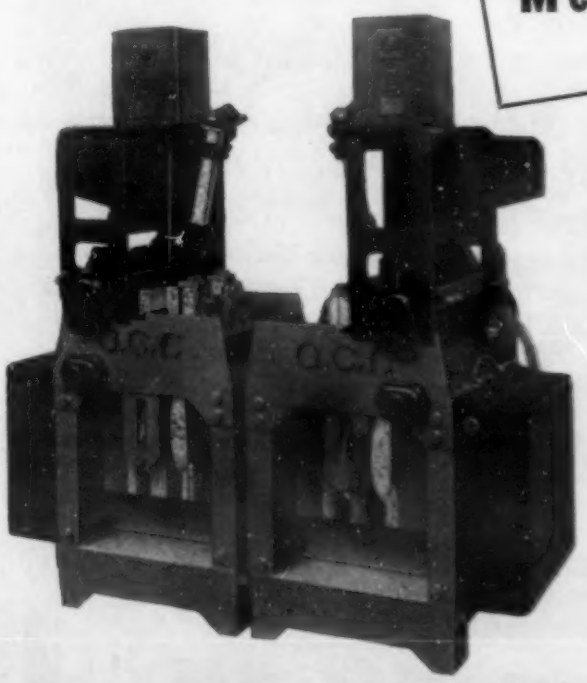

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fluid is on the tool point at all times. A dribble of cutting fluid striking a hot tool tip will cause the hard metal tip to crack.

Shell forgings should be carefully examined to detect excessive variation in size, concentricity, hardness, and scale. Any large irregularities may destroy an entire set of carbide tools.

As much standardization of cutting tools as possible should be made. A wide range of accurately-sized, cold-drawn shank steel sections is available. Non-standard cross sections require costly shaping, milling and grinding.

On resharpening, the original tool form, including rakes, clearances, and chip curling grooves, should be carefully retained. Careless and improper grinding can do more than any other abuse to reduce the productivity of carbide tools.

The comparison between World War I and today's production of shell is interesting. Cutting speeds with high-speed-steel tools used 26 years ago were around 45 ft./min. Coarse feeds of from 1/10 in. to 1/8 in. per revolution were necessary to get the required rates. The machines were largely engine lathes or single-purpose machines and the machining operations were performed successively rather than simultaneously, usually employing one tool at a time. Stress was laid on bursting characteristics rather than upon the machinability of the steel used.

Now, automatic machines are employed. Cutting speeds and feeds are around 300 ft./min. at 0.02 in. feed per revolution for rough-turning. There has been considerable improvement in the machinability of shell steel still retaining satisfactory bursting characteristics, and the number of tools working on the shell at the same time has increased to 4, or even 6. HRC (2a)

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Sparks from Aluminum-Painted Steel

"Ignition by Sparks from Aluminum Coated Metalwork." T. S. E. Thomas. *Foundry Trade J.*, Vol. 65, Sept. 25, 1941, pp. 206-208. Practical.

Attention is called to the danger of heat treatment after painting. It has been reported that sparks have been observed in certain industrial establishments when steam pipes and steam-heated vessels coated with aluminum paint have been struck or scraped with a tool of steel, copper, bronze or brass. Only a light blow or scrape was found to be necessary to produce the effect.

Experimental work on the subject has brought out several points. First, the effect occurs only when the steel surface before being painted is rusty; careful preliminary cleaning eliminates the sparking. After the rusty specimen has been painted, it must be subjected to a temperature in the neighborhood of 265° F., before sparking can be obtained.

No sparks could be obtained from a specimen of rusty steel, painted with an ordinary oil-vehicle aluminum paint, which had not been heated though the specimen had been kept for 1 yr. at laboratory temperature before being tested. Once the specimen has been heated after being painted, the temperature of the steel when struck has little or no effect on the character of the sparks obtained, i.e., the effect achieved by suitable heat-treatment persists at normal temperature.

It was suggested that the phenomenon was a miniature thermit reaction between flakes of aluminum and the particles of rust, which are intermingled at the interface, the reaction being started by the heat generated at the point of impact between the metal tool and the iron surface. Also, with painted metal that had not been heated before trial, the vehicle in the paint acted as a lubricant—so reducing the temperature rise at the point of impact and at the same time preventing intimate contact between aluminum flakes and particles of rust, that the effect on the specimen of initial heating was the destruction of the vehicle and the consequent elimination of its preventive role.

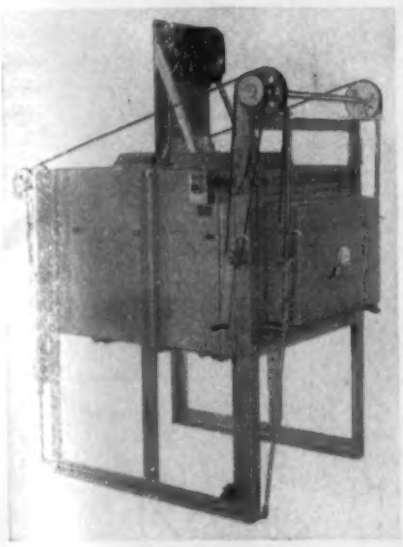
Tests made with ordinary oil-vehicle aluminum paint, with paints containing a cellulose base, etc. are discussed. The use of aluminum paint to cover rusty steelwork does not give rise to any danger from sparks, on impact with a piece of hard metal, if commercially-produced paints of the types described are used, unless the metal is heated to 300° F., or upwards subsequent to being painted. However some incorrectly made paints can be dangerous without heating of the metalwork. AIK (2a)

2b. Non-Ferrous

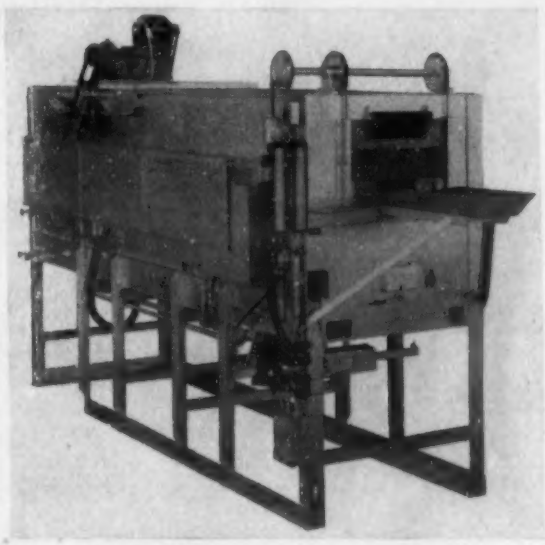
Powder Metallurgy of Brass

"Some Properties of Sintered and Hot-Pressed Copper-Zinc Powder Compacts." Claus G. Goetzel (Am. Electro Metal Corp.) *Am. Soc. Metals*, Preprint No. 9, Oct. 1941 meeting, 32 pp. Research.

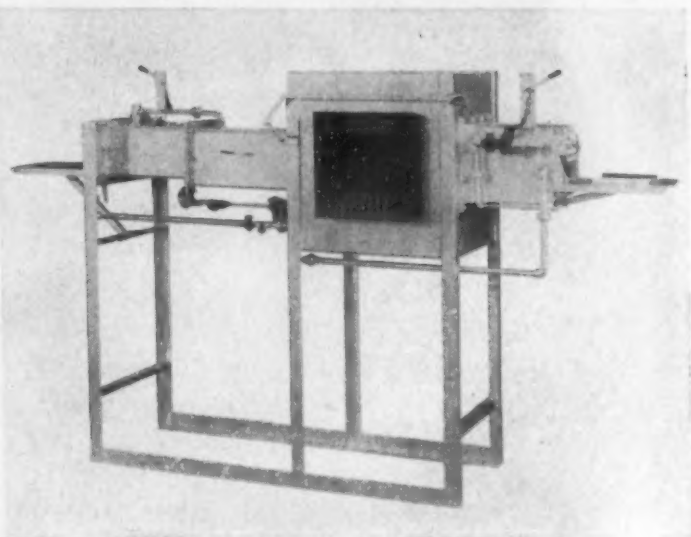
Brass compacts with different percentages of zinc were prepared by powder metallurgy



TEMPERING



CONVEYOR HARDENING



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processing of metal powders and of alloy powders. The effects of composition, raw materials, molding pressure, etc. on the properties of finished compacts were investigated, and a comparison was made between pressing-and-sintering on one hand and hot-pressing on the other.

The inferiority of compacts hot-pressed from *alloy powders* as compared to similar compacts made from *mixed copper and zinc powders,* as found by Jones, could not be affirmed. In general, compacts made from previously alloyed powders showed a better diffused structure and superior physical properties for either sintered or hot-pressed material.

Hot-pressed brass compacts displayed physical characteristics generally superior to those obtained with *sintered* alloys of the same composition. Although the structure of hot-pressed material still lacked uniformity, the density figures reached peak values closely approaching the normal densities of cast or wrought brass.

Hardness figures of hot-pressed compacts exceed by far similar properties of sintered brass. At high pressures and low pressing temperatures (575° F.), exceptionally high hardness values were obtained—comparable to those of severely strained wrought brass. Hardnesses may still be increased, perhaps up to 200 Brinell, if finer raw material powders are used.

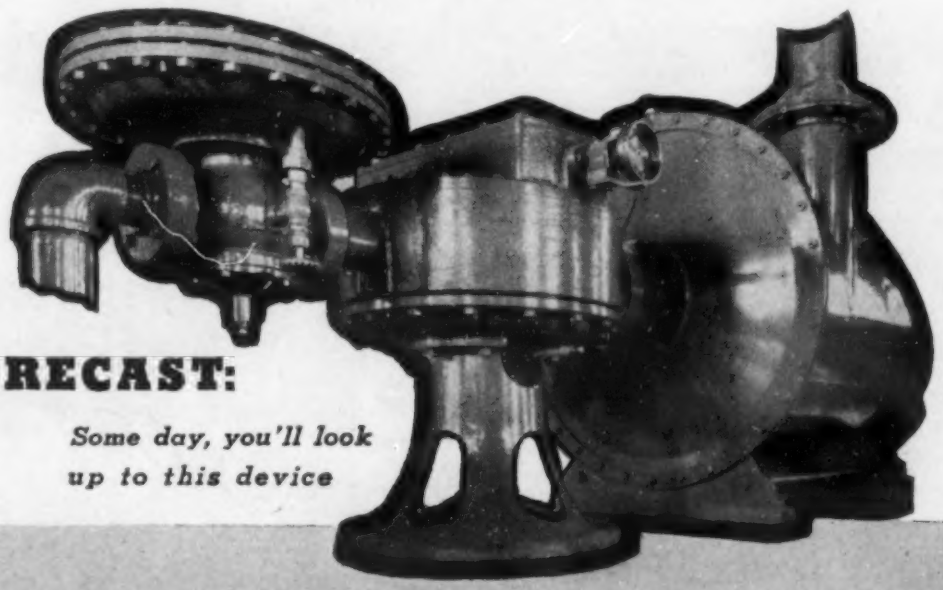
Hot-pressed brass compacts maintained their dimensions within closed tolerances regardless of the temperature or pressure used in the work. After compression of more than 2,000 compacts in the same die at temperatures up to 1110° F. and at pressures up to 50 tons/in.,^{2} the $\frac{5}{8}$-in. diam. of the resulting compacts had increased less than 0.001 in.

On the other hand, changes in volume were found to be considerable in the case of sintered brass. In general, sintered brass compacts increased their volume less if prepared from alloy powders.

Diffusion of the copper and zinc depends greatly on the treatment of the compacts. Attempts to produce alloying by sintering a mixture of powders at 840° F. (just above the melting point of zinc) were only partly successful. Complete diffusion, it seems, may occur only above 1110° F. On the other hand, completely alloyed powder may be more difficult to press, either hot or cold.

Composition changes have certain interesting effects on the properties of brass compacts. Density decreases with increasing zinc content. Hardness, however, rises with increasing zinc content for hot-pressed material and drops for sintered material. With the 55% Cu, 45 Zn composition, hot-pressed compacts prepared from mixed metal powders had extremely high hardness, probably attributable to the presence of a hard, brittle zinc-rich phase in the structure.

The powder metallurgy of brass offers a wide and interesting field. The fact that *sintered* brass compositions are subject to dimensional changes constitutes a major handicap to the full industrial development of such materials. *Hot-pressing* methods for brass, however, are very promising; aside from the fact that dimensions can be more closely held, high-zinc commercial alloys are more ideally suited to hot-pressing because of their greater plasticity at high temperatures. FPP (2b)



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Aging of Cold-Rolled Brass

"The Precipitation Reaction in Aged Cold-Rolled Brasses: Its Effects on Hardness, Conductivity and Tensile Properties." R. H. Harrington & T. C. Jester. *Am. Soc. Metals,* Preprint No. 30, Oct. 1941 meeting, 19 pp. Research.

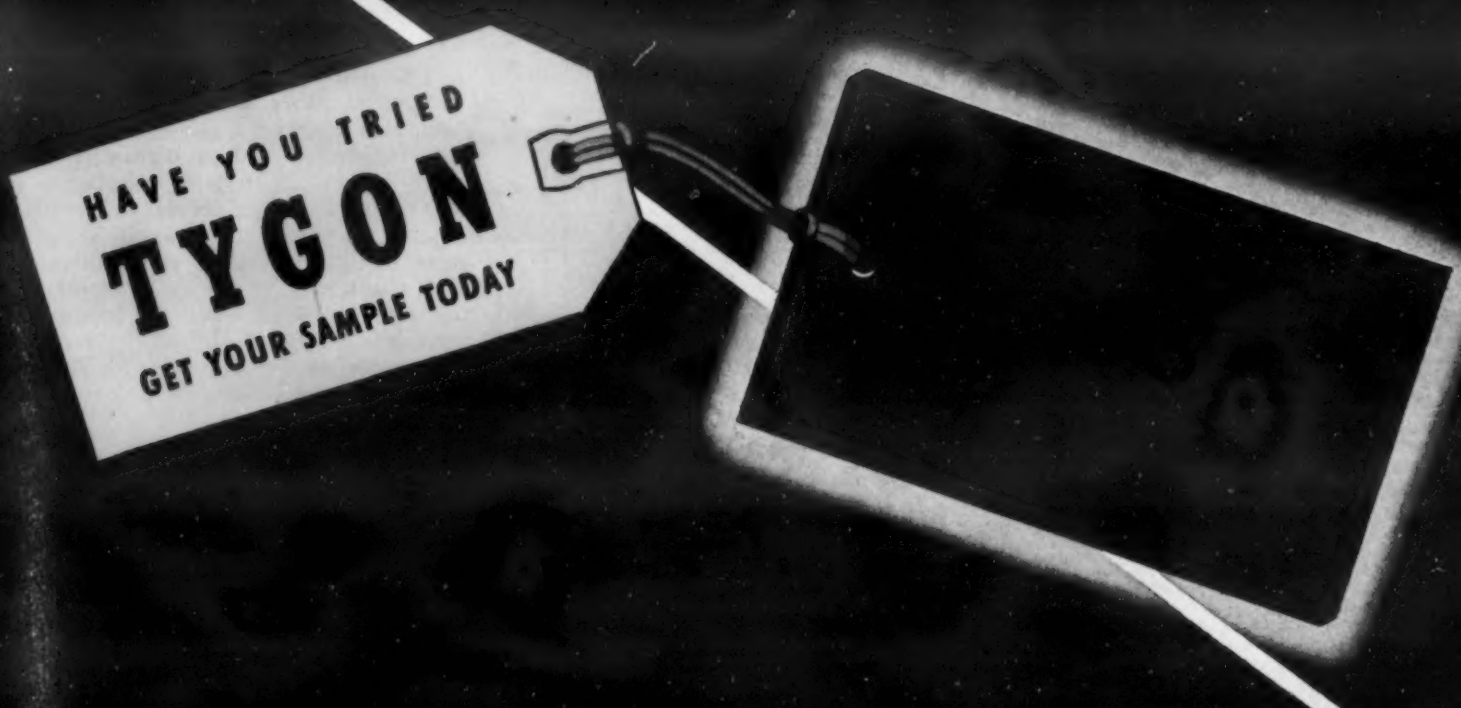
As previously reported for the case of phosphor bronze, aging below the recrystallization temperature results in a combined increase in elastic properties, elongation, fatigue resistance and electrical conductivity for the cold-rolled brasses. Data are given for commercial 85/15 and 65/35 brasses in two conditions of cold work.

It seems well established that plastic strain induces a precipitation reaction in brasses at elevated temperatures below the recrystallization range. The precipitated phase acts to block the diffusion necessary for recrystallization, and as a result higher service temperatures can be employed with the cold-rolled material than would be obtained if the material were free to recrystallize unhindered.

For the best elastic spring properties for the 4 numbers hard 85/15 brass, a precipitation treatment of 4 hrs. at 390° F. is indicated, while a treatment of 4 hrs. at 480° F. promises the best endurance properties. The best properties for the 8 numbers hard material appear to be developed by a treatment of 4 hrs. at 390° F.

For the 65/35 brass 4 numbers hard, the best combination of properties appears to be developed by the precipitation treatment of 4 hrs. at 480° F. The best properties for the 8 numbers hard result from the precipitation treatment of 4 hrs. at 390° F. A doubling of the proportional limit in this last instance checks the earlier observations by Moore and Beckinsale. FPP (2b)

TYGON *geared to the impossible*



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Heat Treating Aluminum Alloys

"The Heat Treatment of Aluminum and Its Alloys." *Foundry Trade J.*, Vol. 65, Sept. 25, 1941, pp. 205-204. Review.

Solution heat treatment of aluminum alloys consists of heating the material at the prescribed temperature (usually near 975° F.) in either a salt bath or a suitable muffle, followed by rapid quenching in water or oil. It is hardly necessary to stress the need for keeping heat treating temperatures within specification limits. However, the best mechanical properties are usually obtained by heat treating at the highest permissible temperature, and in many cases attempts to apply this principle have led to trouble through accidentally over-shooting the upper limit.

The obvious danger of using too low a solution heat treatment temperature is that complete solution may not be effected in the time available. The temperature range for each specification has been very carefully chosen, and cracking of the material will almost certainly occur if it is exceeded. The coarser structure of castings makes very much longer soaking periods necessary, 12 hrs. being a common time.

The choice of solution heat treating equipment may be influenced by the form of product being treated, but the types most generally in use are gas, oil or electrically-heated baths containing either fused sodium nitrate or a mixture of sodium and potassium nitrates, and air furnaces in which the air, heated by various means, is forced by means of fans to circulate through the load at high speed.

Each type has its advantages and disadvantages, but the fused salt bath is probably the most widely used in England. Its popularity is largely due to its high heat capacity, which ensures that the material being treated rises very rapidly to temperature, and with reasonable care uniformity of temperature is easy to obtain.

High speed air furnaces have been increasingly used in recent years, and satisfactory results are obtained, provided attention is given to efficient spacing and furnace atmosphere. If gas or oil is the heating medium used, it is essential that the products of combustion should not come into contact with the metal.

The temperature of a heat treatment furnace is likely to vary during its operation, and whether a salt bath or forced air-type furnace is used, an occasional "temperature survey" with a thermocouple is advisable in order to locate and correct hot or cold zones. In salt baths, dross settlement on the bottom of the bath can easily give rise to hot spots, and a periodic cleaning-out of sludge from the bottom of the bath is desirable. Hot or cold zones can be caused in air furnaces by damage to baffles and blockage of air passages by scrap or dust.

Quench water is usually kept at a temperature not greater than 78° F., unless specified otherwise, and a separate tank with circulating water should be used for washing. If hot, the wash water should not exceed 150° F. The tendency of nitrate to absorb water makes it necessary to remove all traces of the salt from the metal to avoid subsequent corrosion troubles. Soft water should always be used when available.

The time lapse that occurs when transferring the material from the furnace or salt bath to the quench tank is a factor that may have considerable effect upon the properties of the heat treated alloy part. This interval should not be allowed to exceed 10-15 sec. for large loads, and less for small loads and single sheets.

The precipitation heat treatment required for the artificially-aged alloys is carried out on completion of the solution treatment by heating at a moderate temperature (near 300° F.) which varies somewhat with the composition of the alloy. Air furnaces are almost exclusively used, circulation of the air by fan being essential. The process increases the ultimate tensile strength, proof strength and hardness, and decreases the ductility and usually the impact strength of an alloy.

The practical considerations applying to precipitation treatment are similar to those for solution treatment. Temperature ranges should be rigidly adhered to, and loads should be carefully spaced in order to maintain uniform temperature conditions. It is advisable to pack thermocouples in with the material in order to check the time at which uniformity of temperature is reached.

When dealing with heavy masses of material, cooling, preferably by means of cold air blast, should be carried out as soon as the load is withdrawn from the furnace, as slow cooling is equivalent to an extension of the aging period, and may result in inferior properties. This is not necessary where well spaced loads or built-up structures are concerned, since these have a larger surface area for heat dissipation.

AIK (2b)

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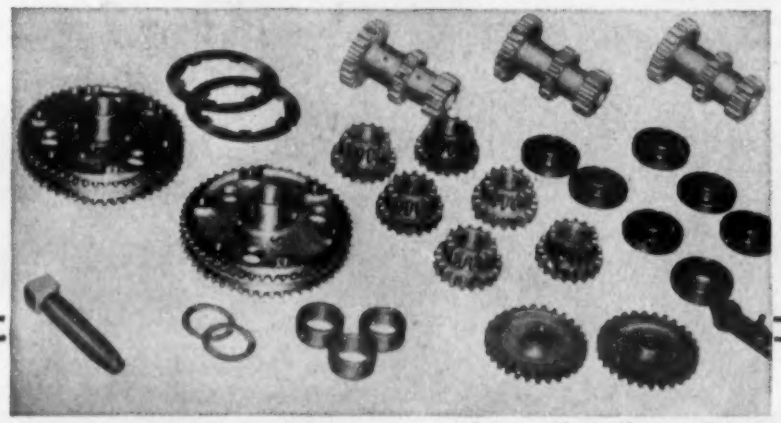

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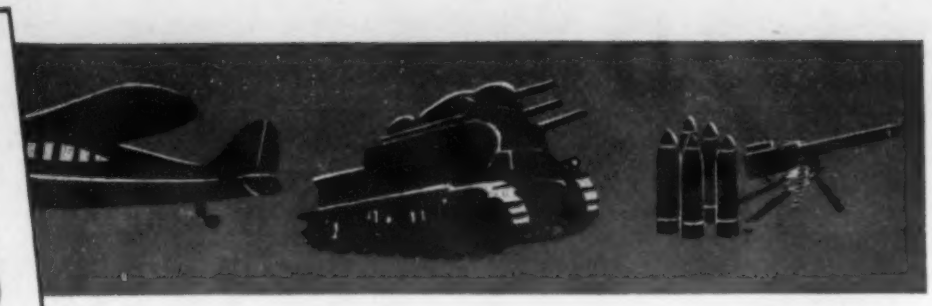

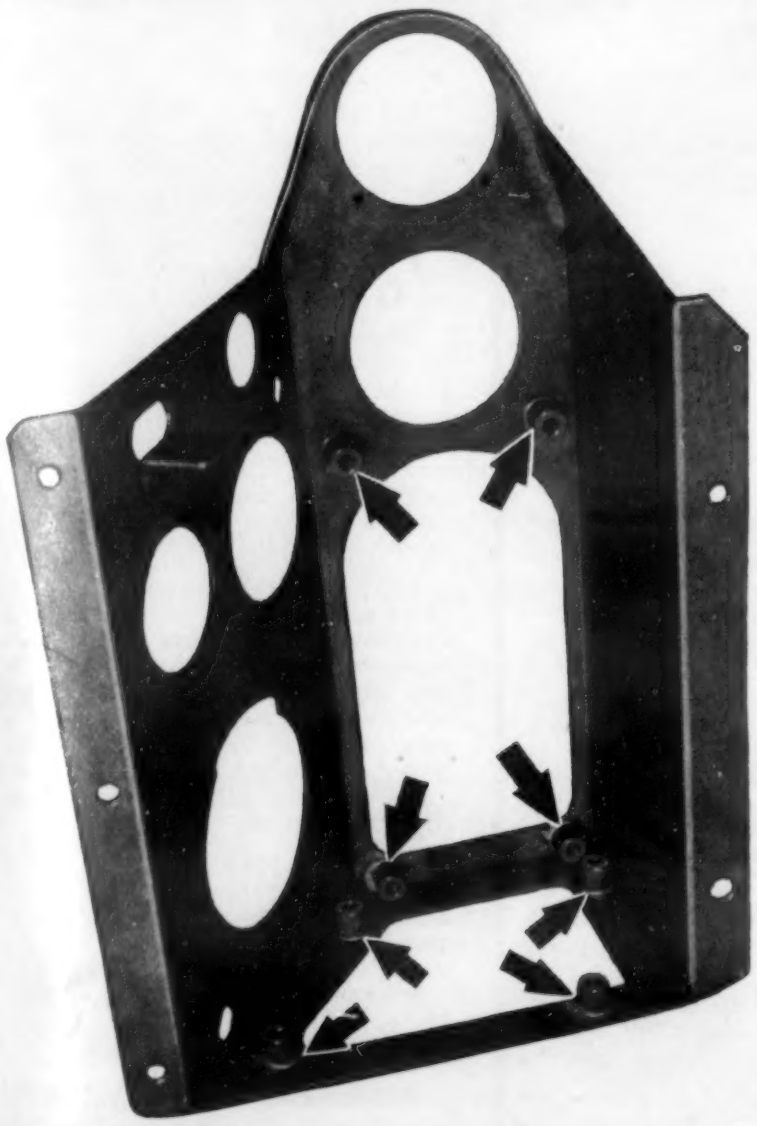

EASY-FLO *brazing cuts time on this job over 60%*

At the left you see a dashboard for a Bren-gun carrier. The job is brazing steel spuds to a mild steel frame. Formerly spuds were positioned with a fixture and then welded on two sides. Now, the spuds are positioned as before but are brazed with EASY-FLO.

Here's what the manufacturer reports the change to EASY-FLO has accomplished—

Time per 1000 panels by the former method—88 hours welding—53 hours for cleaning etc.—total 141 hours.

Time per 1000 panels by EASY-FLO brazing—total 53 hours. Cleaning entirely eliminated.

Estimated reduction in cost per 1000 units $49.50

The truly amazing extent to which EASY-FLO is now used is due to the fact that it has speeded up production and reduced costs for nearly every manufacturer who has tried it.

HERE'S HOW YOU CAN QUICKLY FIND OUT JUST WHAT EASY-FLO WILL DO FOR YOU

If metal joining enters into your production it is very likely that you have a number of jobs on which EASY-FLO will give better joints with substantial time savings. If it's defense work, this makes it doubly important for you to get full details. We're ready to do our part by sending a field engineer on request, to help you try EASY-FLO on any ferrous, non-ferrous or dissimilar metal joining job you select.

For full EASY-FLO details write for Bulletin No. 12.

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Substitutes in Sheet Metal Work

"EMERGENCY SUBSTITUTES FOR METALS." CHARLES P. BALSAM. *Sheet Metal Worker,* Vol. 32, Oct. 1941, pp. 30-33. Descriptive survey.

Already many substitutes for metals are available, but many are being so rapidly adopted that a shortage of the substitutes may occur at some future date.

In the sheet metal field many of the new materials can be adopted without any basic or fundamental changes. Some of the substitutes for flat sheets are: for duct work—plywood and duct board; for sinks and water tanks—waterproofed plywood; for solution tanks—transite, glass or resin-lined plywood tanks; for ventilating systems—transite and plywood; and for corrosive work—coated plywood.

For metal roofing, the substitutes include transite sheets, sheet asbestos board and painted plywood. Alternates for the manufacture of furnace casings, bake ovens, pulleys, blower blades, etc., are plain and treated plywood, duct board, asbestos sheeting and board. Plastic pipe has been sufficiently perfected for many varied uses.

Plywood is almost the universal substitute for sheet metal. It can be easily formed and bent to shape and is sufficiently strong for many uses. Plywood can be stamped out with metal dies using a regular metal punch press. It can be cut with a power shear, riveted and punched the same as sheet metal and it will hold nails and screws much better than ordinary metal.

The various kinds of duct board are made up of asbestos fibre. It is fireproof, sound absorbing, and is usually not affected by corrosive fumes or moisture. Transite is a very dense material made of cement and asbestos under terrific pressures. It is fireproof and can be cut with a saw and drilled. Transite has long been available in round pipe for flue pipe connections and city water systems.

It is highly essential that the dealer and manufacturer perfect the technique and methods of using these sheet metal substitutes so that as the shortage takes place, service to the public will not be interrupted.

HRC (3)

Pre-Formed, Pre-Finished Metals

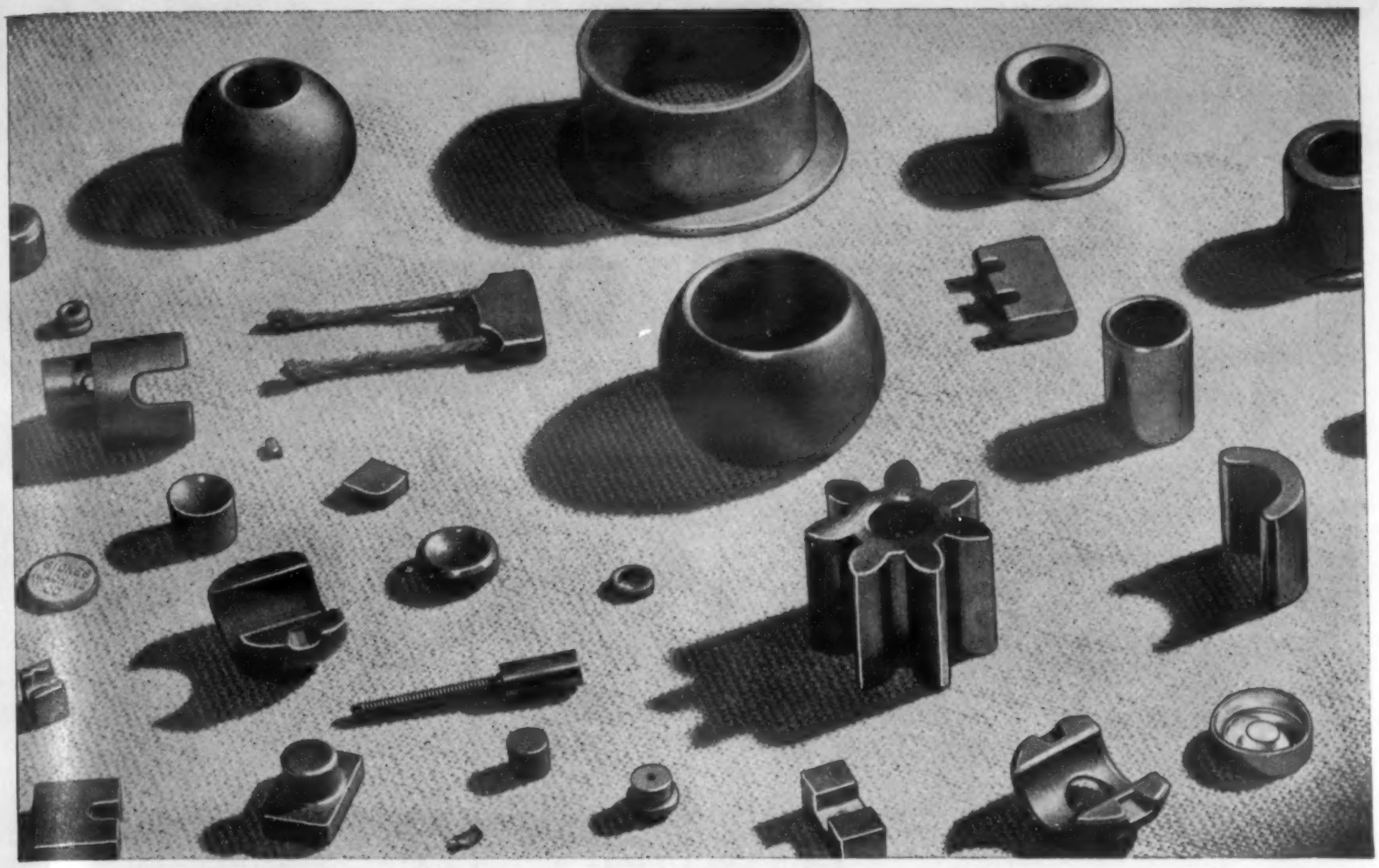
"PRE-FORMED, PRE-FINISHED METALS SAVE MATERIALS AND LABOR." *Electrical Manufacturing,* Vol. 28, Nov. 1941, pp. 44-46, 80, 90. Survey.

The defense program is absorbing many of the best machinists and die-makers as well as many vital materials. This involves the adoption of substitution programs for consumer goods that must consider both materials and labor. Preformed and pre-finished metals can do much to alleviate the tight situation.

Metals of various kinds are made available in pre-formed shapes. The extrusion process will prove of increasing value in product construction throughout the emergency. Extruded metals can be obtained in a wide variety of cross sections, permitting the metal to be placed where it will be most effective. At the same time, the labor of highly skilled workers is conserved.

The use of die castings is limited, among other things, by the shortage of die makers. Many shapes may be drawn from seamless tubing, lockseam and welded tubing, and strip, as replacements for die-cast elements.

In matters of material and shape, the product maker must limit his demands because of shortages. Usually, however, with



Parts Like These in One to Two Seconds

Like many other materials powdered metals lend themselves readily to compressing. Finished products can be completely formed, ready for sintering, in a matter of seconds. Production rates of 10 to 50 or more per minute are usual for parts such as copper motor brushes, porous bearings, contact points, etc. Rates of several hundred per minute are often possible, depending on the size of the part, its form, material and pressure required and the machine used.

With Stokes Automatic Presses, developed especially for compressing powdered metals, intricate as well as simple parts are being produced . . . half bushings, thin rings, flanged bushings, Alnico magnets, iron radio cores, iron gears, etc. These parts are dense and of uniform accuracy, made under identical conditions of fill and pressure. Density is accurately controlled, with pressure applied from top and bottom simultaneously or separately as may be required.

Stokes Presses for powder metallurgy are rugged, powerful, practical and productive . . . the result of many years of research and development work with engineers in this field. Built into them is our more than 40 years' experience in the manufacture of automatic press equipment for forming chemicals, explosives, pharmaceuticals, ceramics and other materials.

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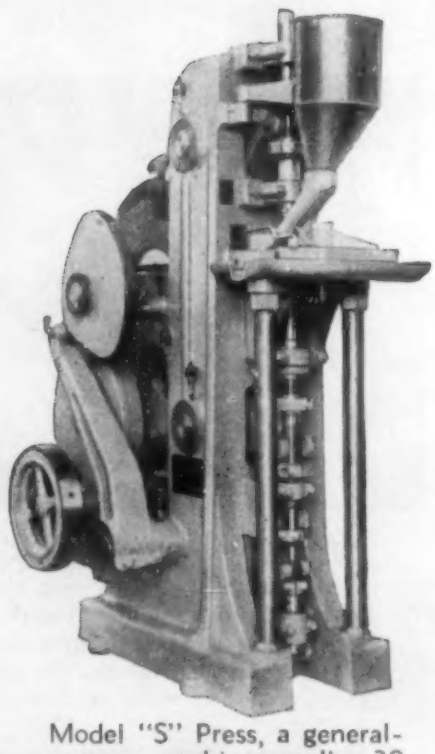

Model "S" Press, a general-purpose machine, applies 30 tons pressure. Output up to 35 pieces per minute.

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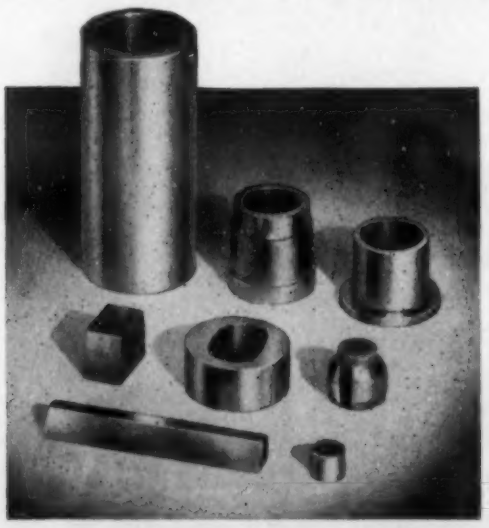
complete information on the purpose of a specific product, a satisfactory composition of material and shape can be worked out without an appreciable decrease in quality.

Cold-rolled strip steel is sure to find an increasing field of application for use in substituting for restricted special metals and forms. In using cold-rolled sheet, there are a number of tempers available, each suited to special uses. These should be considered and the choice of the temper governed by the kind of forming employed and the use to which the product will be put.

Where protection against corrosion is required, stainless steel was very often used. Now that metal is limited almost entirely to defense uses. "Stainless-clad" steels are now being adopted where only one side of the product is subject to corrosion. Since the bond between the cladding and steel is permanent, the clad steel can be fabricated by any of the ordinary means. It can also be easily welded. Stainless-clad steel is being accepted for use in many types of household devices where chromium and nickel plating were formerly used.

In the matter of finish, the product manufacturer must make some sacrifice. Electroplating for non-defense products will soon be eliminated. To lick this restriction, extruded tube or sheet forms that possess a natural satisfactory finish will have to be adopted. Zinc-, copper-, brass- and tin-base metals have this property.

Pre-finished bonded metals in sheets or coils will be increasingly employed as substitutes for platings and colorings. The pre-finished bonded metals are especially applicable to the construction of domestic articles where appearance is a valuable sales factor. The stainless-clad steel may also be considered as a pre-finished metal highly desirable wherever corrosion resistance is required. HRC (3)



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3a. Ferrous

Stainless Steel Wire in Aircraft

"Stainless Steel Wire in Aircraft." J. K. Findley (Allegheny-Ludlum Steel Corp.) *Wire & Wire Products*, Vol. 16, Oct. 1941, pp. 581-584. Descriptive.

Stainless steel with its high tensile strength, good toughness, resistance to salt air corrosion, low magnetic permeability, and fair ductility make it highly favorable for use in such aircraft parts as springs, pins, wire rope, cable ends, terminals, and especially control cord.

Corrosion of the control cord in coastal or oversea planes is always a serious problem. 18-8 stainless wire was found to have much greater resistance to salt air corrosion than galvanized or tinned steel cord. It also has a high fatigue limit, a necessary property where there is continual flexing. The magnetic permeability of stainless cord or wire rope is lower than that of steel, which is an important factor where the cord is near instruments that might be affected by magnetic material. By improved cold drawing practice, tensile strengths of from 300,000 to 345,000 lbs./in.^{2} were made possible.

Besides being used extensively for control cords, stainless steel wire rope is used for anchor ropes, mooring pendants, push-pull controls, and hoisting slings. Molybdenum bearing 18-8 wire offers increased corrosion resistance, and even though the tensile strength is lowered, this type alloy has been adopted for mooring pendants for seaplanes.

An important use for 18-8 chromium-nickel stainless wire, where its corrosion

BUSINESS END

A little piece of high speed steel may not look like much — a tiny dull sort of a jewel in the setting of a magnificent machine — but it is one of the cornerstones of modern mass production.

That high speed cutting tool — in its turn — wouldn't be high speed if it were not for vanadium and chromium. If it is high speed steel, no matter which of the various types, these two elements seem indispensable.

* * *

Vanadium contributes many qualities — toughness, forgeability, machinability, carbide stability at elevated temperatures, grain control. Most important perhaps is its relation to carbon.

It is well-known that increasing the carbon content in high speed steels (within limits) improves cutting capacity and wear resistance. But it is also known that toughness and forgeability are adversely affected and sensitivity in heat treatment is promoted by increased carbon.

However, when added vanadium accompanies higher carbon, toughness, forgeability and heat treatment characteristics are sharply improved. At the same time, the higher-carbon vanadium steel shows tremendously enhanced cutting capacity and wear resistance. No other element has been found to have these effects in any comparable degree and there is no other known way of obtaining these essential properties without the use of vanadium.

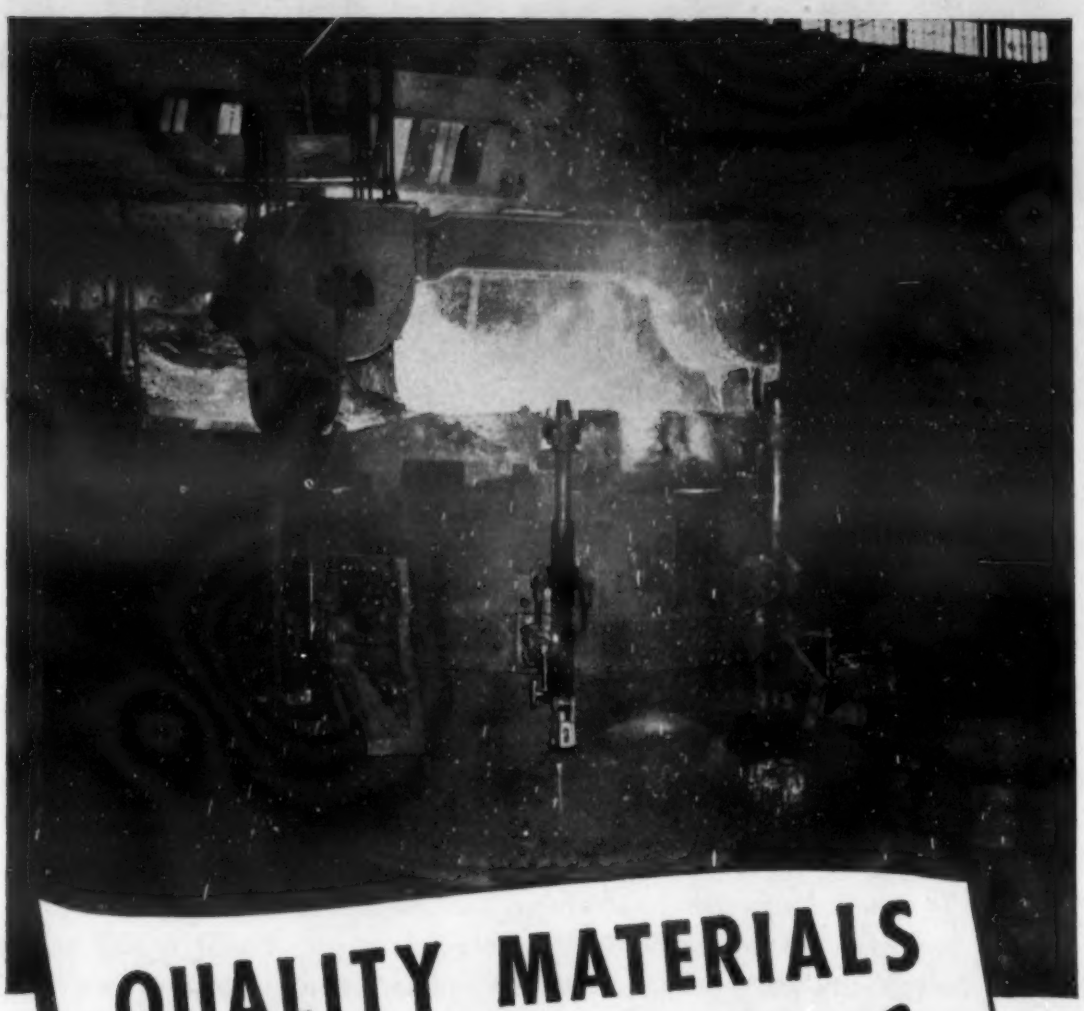
Not only is this true in the tungsten types, but also in the molybdenum high speed steels which are playing such a vital and timely part in the defense program. The vanadium content is generally increased in the molybdenum types to inhibit grain growth at heat treatment temperatures and to stabilize carbides.

* * *

Chromium, likewise, is indispensable in all high speed steels for its effect on hardening. This contribution of chromium is frequently ascribed to its aid in promoting rapid solution of the carbides of the heavier metals during heat treatment, without which hardening would be slow or ineffective.

Of both vanadium and chromium, the Vanadium Corporation is one of America's principal producers.

VCM
FERRO-ALLOYS



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resistance is a negligible factor, is in the stranded high tension magneto ignition cables. Dead soft 18-8 wire is used with a tensile strength of around 90,000 lbs./in.^{2}

The free machining modification of 18-8 alloy with its good corrosion resistance, high strength, and non-magnetic properties, is being used for machine screws, pins, and shafts in the numerous navigating aircraft instruments. Springs, requiring low magnetic permeability and little change in strength and stress characteristics at temperatures up to around 350° F., are also being made of stainless.

The larger diameter stainless steel wires from ⅛ in. diam. to fair size bar dimensions are being applied for streamlined aircraft tie rods. Another application of the stainless rod is for the fittings which fasten together the wire rope or connect the wire rope to movable or stationary portions of the ship. One end is made in the form of a sleeve into which the cable end is inserted. The sleeve is cold swaged to squeeze the metal down into the valleys of the wire rope, making a firm connection between the cable and fitting.

Further improvement in stainless steel and its applications in aircraft construction are desirable, and research indicates that advancements will still be made. HRC (3a)

Hydrogen as an Alloying Element

HYDROGEN AS ALLOYING ELEMENT ("Wasserstoff als Legierungselement") E. HOUDREMONT & P. A. HELLER. *Tech. Mitt. Krupp. Forschungsber.*, Vol. 4, May 1941, pp. 117-126. Original research.

In order to determine if hydrogen can be considered as an "alloying element," a pearlitic cast iron (2.86% C, 2.21 Si, 0.73 Mn, 0.37 P and 0.07 S) in the form of rods 1/16 in. in diam. and 4 in. long was heated at 1830° F., in a current of hydrogen and cooled in the furnace.

The results show clearly that hydrogen acts in cast iron as an alloying element—specifically as a carbide stabilizer. Nothing definite could be established as to the mechanism by which the effect is brought about. The hydrogen-containing samples show a perfect lamellar pearlitic structure, in addition to graphite. Hydrogen apparently maintains an undercooled structural state as compared with the stable structural condition.

The action of hydrogen on steel is similar, and as a result it increases the hardenability. The treatment of abnormal steels with hydrogen leads to the formation of normal cementite and pearlite structure, which is also identical with the action in cast iron.

It is therefore concluded that hydrogen as an alloying element has an effect similar in nature to but different in degree from that of manganese or chromium, excepting, however, the special action of these elements in cast iron. Ha (3a)

Properties of Stainless Steels

"STAINLESS STEEL." J. M. BANDEL (Electro-Metallurgical Co.) *Iron Age*, Vol. 148, Oct. 9, 1941, pp. 45-52, 162-163. Experimental.

New test data and procedure for comparing physical properties of rolled chromium-nickel stainless steel strip are given together with recent experiments conducted on

Because of its high strength and high endurance limit, annealed Everdur 1010 tube is being used for aircraft gas and oil lines, as well as high pressure hydraulic lines.

The ten-point metal of a thousand uses

1. Tensile strength comparable to mild steel
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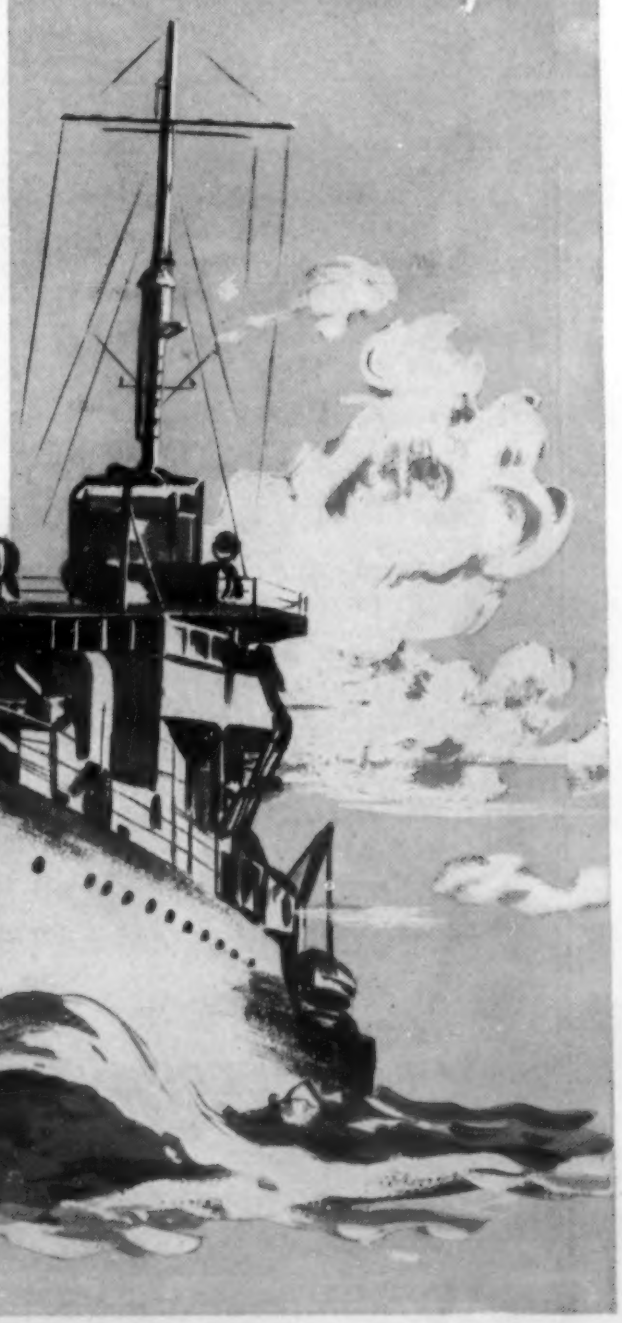
7. Non-magnetic . . . important to manufacturers of electrical equipment
8. Available in all commercial forms
9. A "premium metal at a moderate price"
10. An Anaconda Product...meaning top quality . . . that's Everdur, The American Brass Company's group of copper-silicon alloys! 41160

*Everdur is a trademark of The American Brass Company, registered in the United States Patent Office.

At sea, strong, tough, corrosion-resistant Everdur Metal is used to reinforce mine sweeper hulls, as tanks in submarines, and for elevator and control apparatus for battleship gun mounts.



Process equipment for the manufacture of chemicals and powder is fabricated from easy-to-weld, non-rust Everdur Metal — as are hot water storage heaters at many of the Army camps.

chromium-manganese-nickel alloys. Longitudinal and transverse mechanical properties (with and without heat treatment) of an 18% Cr and 8% Ni composition, and of a 17% Cr, 7% Ni analysis, were investigated after various degrees of cold work. Tests to determine longitudinal mechanical properties were also conducted on 2 austenitic alloys in which some of the nickel of the 18 Cr, 8 Ni alloy was replaced by manganese.

Test results show that annealed material exhibits little, if any directional effects. However, after cold working, the transverse ultimate tensile strengths of 18-8 are greater than the comparable longitudinal values, and low temperature heat treatment improves this property. The ultimate tensile strengths of 17-7 do not exhibit marked directional effects or response to low temperature heat treatment.

The greatest compressive yield strengths of 18-8 and 17-7 after cold rolling are obtained in the transverse direction and there is considerable improvement in these properties by low temperature heat treatment. In order to utilize the properties in this direction, sections made from the strip must be fabricated in such manner that the maximum length of section is approximately the maximum width of rolled strip.

At any ductility level, the corresponding values of tensile strength, tensile yield strength and compressive yield strength are greater for 17-7 alloy than for the 18-8 alloy. Strip having an elongation of 10-15% in 2 in. has sufficient ductility to permit the necessary bending incident to fabrication, and at this elongation heat treated 17-7 alloy has (longitudinal) tensile strength, 193,000 lb./in.^{2}; tensile yield strength, 173,000 lb./in.^{2}; and compressive yield strength, 155,000 lb./in.^{2}

As the nickel is increased in both series of alloys, the rate of work hardening increases. Corrosion tests in boiling 65% HNO_3 on as-cold-rolled stock and after cold-rolling and heat treatment showed that low temperature stress relieving heat treatment did not affect the corrosion resistance. Excellent mechanical properties can be obtained in austenitic chromium-nickel stainless steels by cold work and proper heat treatment. The chemistry of these steels is important as it affects the tendency of the austenitic structure to transform into ferrite, which affects the rate of work hardening and hence the mechanical properties.

VSP (3a)

COMPARING METAL-FORMS

Designing for stampings . . . . designing for die castings . . . . designing for forgings . . . . deciding whether to stamp it or die cast it or forge it or screw-machine or make it by powder metallurgy—these are metal-design problems to which M & A, recognizing their peculiar metallurgical engineering character and great importance, pays very special attention editorially. Here is a list of some recent feature article material of this nature: "Permanent Mold and Die Castings Compared" in August and November 1941; "Role of Plastics," "Steel Castings," "Gray Iron in Product Design," "Welded Design," "Screw Machine Products," and "Drop and Upset Forgings"—all in the October 1941 issue; "Powder Metallurgy—1941 Model," in November, etc. In addition, we've had countless digests—e.g. "Design for Stampings" on this page; "Cast Iron Piston Rings for Aircraft Engines" in November; "Stainless Steel—Welded vs. Cast vs. Rolled" in October; "Designing for Powder Metallurgy" in July; "Extruded Parts" in March, etc.

From the design standpoint, the method of fabrication is often as important as the metals used, and worthy of equal attention.

Design for Stampings

"Use of Stampings to Conserve Strategic Materials." Kenneth D. Mosland (Staff) *Machine Design*, Vol. 13, Nov. 1941, pp. 43-46, 124, 126. Practical.

The current shortage of materials and machines has turned the spotlight on designing to "conserve," and the use of stampings or the stamping process for products manufactured is a major factor in conserving metal tonnages. By no other method of manufacture can wall thickness be maintained as uniform and such economical use of metal be attained.

In less warlike times the decision as to how a part is to be manufactured and the material to be used is usually made on a basis of relative economy. Today, however, availability is more important. Steel, and particularly steel sheet, is, of all industrial metals, under the least supply pressure. Many parts, therefore, may be best made of low-carbon steel sheet, press-formed and coated with non-metallic finishes, and will give satisfactory results.

In developing the design for a stamped and formed steel part, the following factors should be studied: Number of parts required, load to be carried, dimensional limitations in adapting the part to the machine, tolerance limitations on critical dimensions of the part itself, contour, diameter and depth of holes, etc.

The stamping producer should be consulted before the design is established, and he should be given as free a hand in the part design as possible. Especially should this consultation *not* be postponed until the rest of the machine is finished, for the freedom of design to take full advantage of stampings is thereby badly restricted.

Parts that are sheared from an over-width strip can often be redesigned for manufacture from thinner stock available in closely-held widths, thus saving the sheared-off waste material and obviating the shearing operation.

In deciding whether to drill and countersink holes or to punch them, a good "rule of thumb" is that the diameter of a *punched* hole must be equal to or greater than the thickness of steel stock (in non-ferrous metals smaller diameters may be specified). Also, the lower ⅔ of a hole—the "break-away" portion—is torn away in punching, leaving an outward-tapering surface that prevents holding to very close tolerances on hole diameters.

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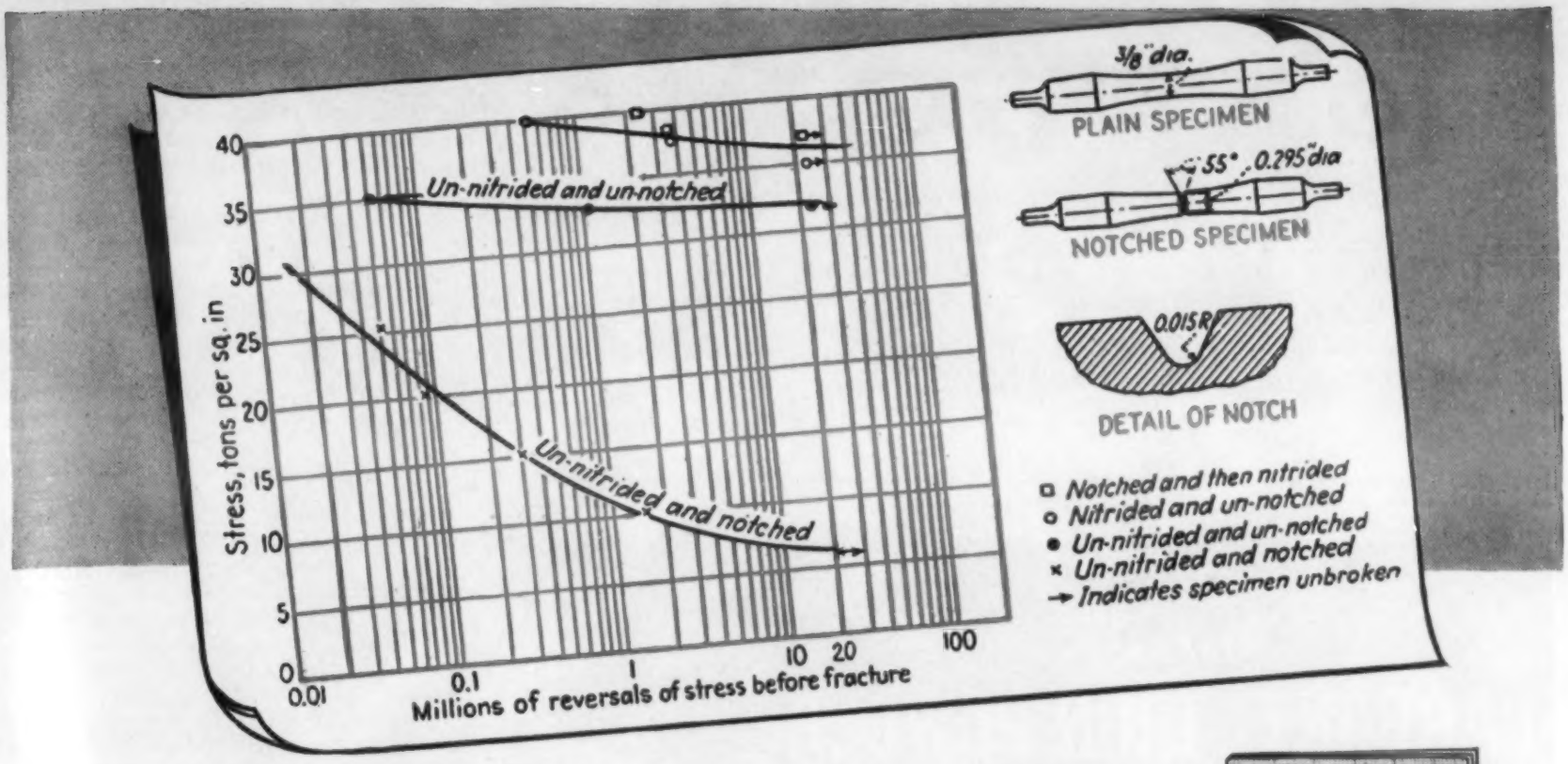


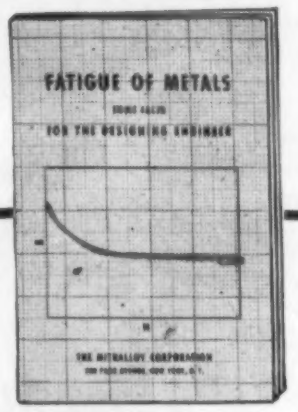
FATIGUE RESISTANCE TOO IS TRUE CONSERVATION

Lengthening the life of machine parts subject to failure by fatigue conserves vital metals for Defense—conserves also the productive capacity, power, personnel and transportation facilities otherwise required for replacements.

High in the scale of metals and methods that increase the fatigue-resisting power of steel, stand Nitralloy and the Nitriding process, widely recognized also as producing the hardest steel surface known.

NITRIDING is the process of case hardening certain alloy steels by means of a nitrogenous medium, such as ammonia gas. The alloy steels that are most suitable for Nitriding are known as **NITRALLOY**

Use Nitrided Nitralloy for steel parts subject to fatigue and frictional wear—to multiply the service life of our defense equipment, to promote the safety of our armed forces, to create more durable production machinery.



WRITE FOR THIS NEW BOOK

by D. Landau, Industrial Applications Engineer of The Nitralloy Corp.

This book is a study of the conditions which increase the resistance of metals to fatigue caused by repeated stresses, and as affected by stress-raisers such as notches, screw threads, keyways, poor fillets, etc. A valuable bibliography supplements the 40 pages of text and charts. Your copy will be mailed promptly with our compliments on receipt of your request to us or to any of the licensees listed below.

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Reference Tables on Materials and Design

Busy metallurgical engineers who make a habit of turning to this section of the digests every month for concise information on materials and product design should be sure to examine and keep for future use the conveniently compressed 2-page reference table on "Alternates and Substitutes in Household Products" on pages 80 and 81 and the comprehensive 8-page tabulation of "New Materials and Finishes of 1941" on pages 83 to 90 of the feature section of this issue. Each contains a wealth of reference information especially applicable to today's design considerations.

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If holes are pierced in a blank too near a bend line, they will be deformed out of round during subsequent forming. A hole edge should be no closer to a bend than the thickness of stock away from the approximate point of tangency of the bend arc to the undeformed, straight section of the material.

In a simple press operation, the lower limit of inside radius of the bend can be taken as not less than the stock thickness. Sharper corners on the inside will require at least one additional press operation with consequent cost increase.

Also, close limits on diameter increase in the breakaway portion can be met only at increased cost. The limits are met by reducing the clearance between the punch and die. Such reduction results in an ironing of the burr that starts in the breakaway and shortens the life of the tools with consequent higher operating costs.

Normal deformation of holes pierced in the blank in or close to a bend or corner radius can be utilized by punching elliptic holes or slots in the blank in such a way that in the drawing operation the holes are deformed to approach roundness.

The flow of metal in the corner of a part during the draw results in thinning of the stock. On the tension side of the bend, the metal is drawn out; on the compression side, it is squeezed out laterally, producing edge irregularities.

The narrower the strip being bent in relation to its thickness, the more pronounced this distortion becomes. In wider strip, irregularities are less pronounced and there is less reduction in stock thickness.

FPP (3a)

3b. Non-Ferrous

Low Temperature Properties of Light Metals

"Mechanical Properties of Alloys at Low Temperatures." *Light Metals*, Vol. 4, Nov. 1941, pp. 212-215. Review.

There are at least two fields of practical engineering importance in which the low temperature properties of alloys are of interest. One is refrigeration, and the other is military or other operations in arctic regions. The production of shrink fits may be considered also in this connection.

While structural changes, particularly of the austenite-martensite type, may be expected to occur in certain steels subjected to very low temperatures, non-ferrous alloys are not susceptible to such drastic transformations. However, the velocity of aging in age-hardenable aluminum alloys is of course tremendously reduced by holding at low temperatures, and industrial use is being made of this fact. The tensile properties of aluminum alloys as a class are very little different at —110° F. compared to those at room temperature: the tensile and yield strengths increase only slightly, and the modulus of elasticity increases somewhat.

Wrought alloys finished by cold rolling show better properties than aged samples. Longitudinal specimens show better properties than those cut transversely to the rolling direction.

With regard to wrought magnesium alloys, yield and ultimate strength are better at —110° F., but the ductility tends to drop somewhat. As the temperature decreases, the hardness of magnesium alloys increases but prolonged exposure has no effect.

The Charpy impact resistance of both aluminum and magnesium alloys is not

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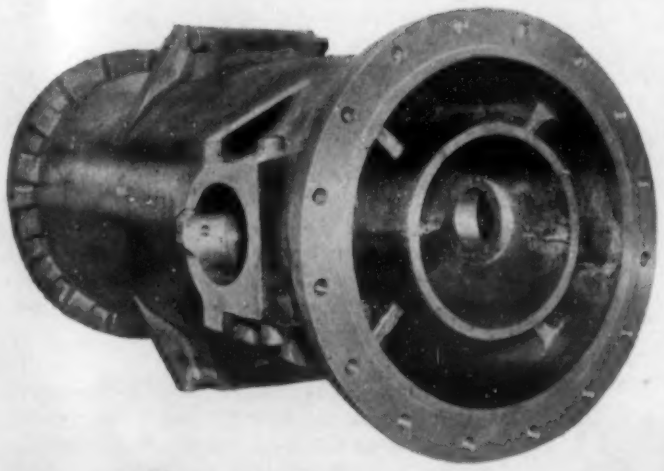

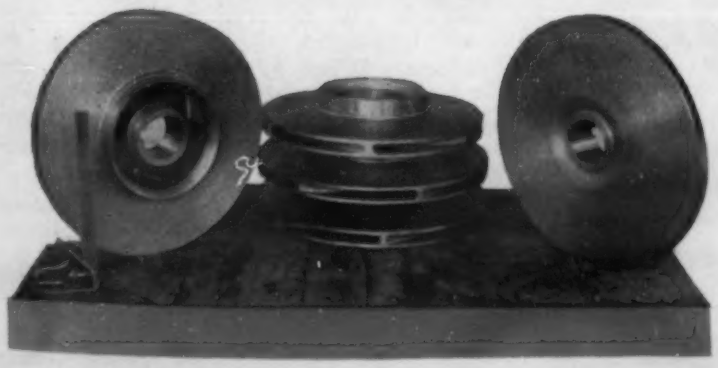

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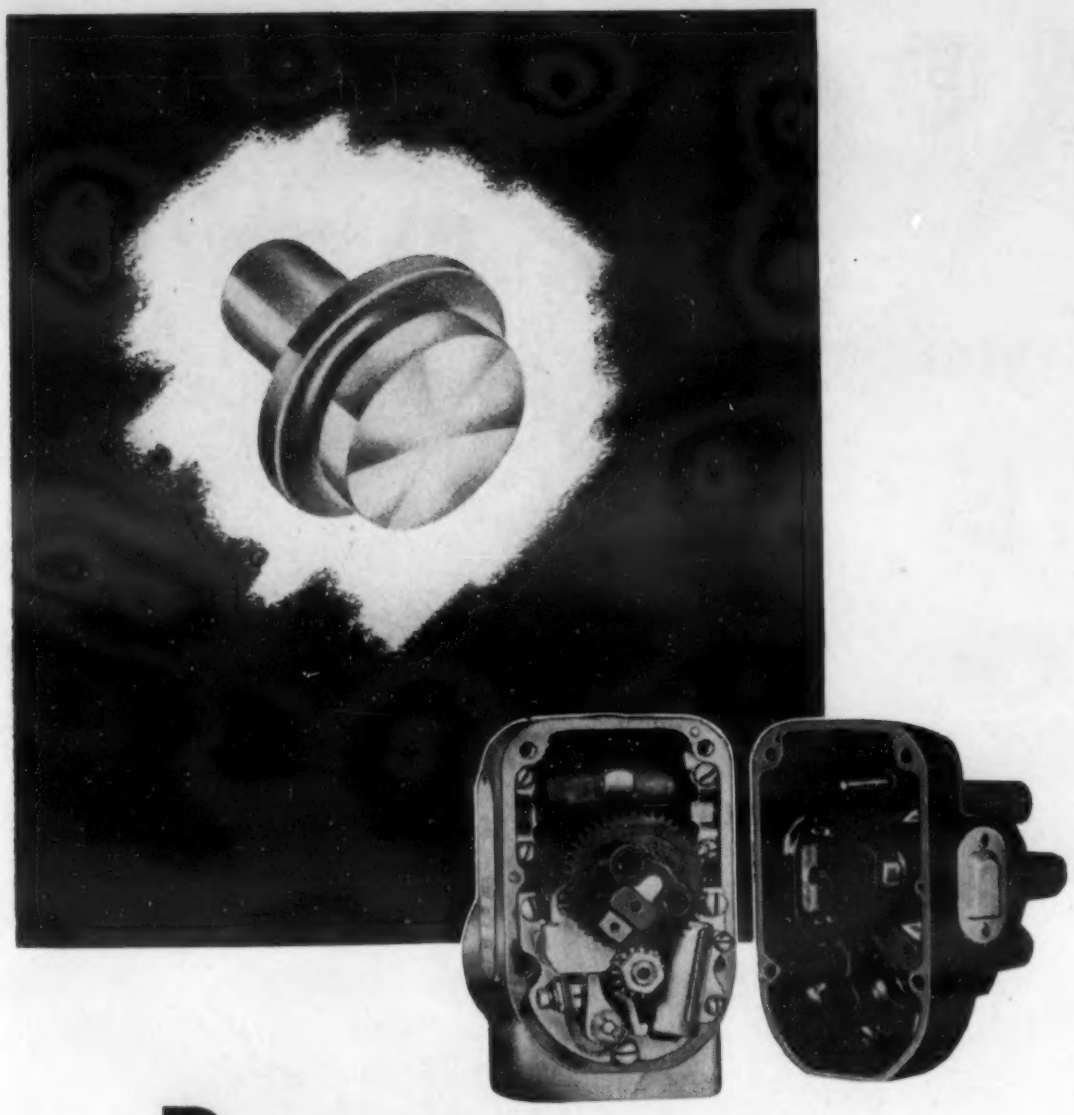

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affected appreciably by temperatures as low as —110° F. While differences between various aluminum and magnesium alloys either in wrought or cast form are not, in general, markedly affected by the test temperature down to —110° F., much lower temperatures bring out more pronounced differences. At —290° F. (liquid air temperature) pure aluminum has a tensile strength 22% over that at room temperature, while the % reduction in area is decreased by 3.8%.

At —180° F., the tensile strength of Y alloy is increased by 15%, rising to 29% at —290° F., while the per cent elongation is raised 25%, and the reduction in area is decreased by 17%. Some other experiments have shown that the tensile strength of Duralumin rose until —140° F. was attained then fell off with lower temperatures. Lautal behaved similarly.

The elastic properties of aluminum and magnesium alloys appear to increase with decreasing temperature, the effect however is apparently very slight in the case of magnesium alloys. The literature of low temperature work on aluminum and magnesium alloys has reached a stage where the rather scattered data should be correlated, and plans made for a study of some of the other fundamental properties such as creep, fatigue, etc., but other aspects of a less fundamental nature should not be neglected.

Certain results might be expected which would be of considerable practical value. Machinability tests on strongly cooled bar stock might conceivably show it to be more readily machinable, for example. This is suggested only as a possible example of improvements that might be found if low temperature properties were studied more exhaustively. AUS (3b)

Sleeve Bearings

SATISFACTORY METALLIC SLEEVE BEARING MATERIALS AS REFLECTED IN RECENT LITERATURE ("Bewährung der metallischen Gleitlager-Werkstoffe im Spiegel des neueren Schrifttums") K. KÜHNEL. *Z. Ver. deut. Ing.*, Vol. 85, Mar. 1, 1941, pp. 201-206. Review.

Recent literature gives support to the thesis that for sleeve-type bearings, best performance is associated with a structure consisting of hard crystals finely distributed in a soft matrix. Lead bronzes of 71-78% Cu, 20-28% Pb, and 1-3% other additions have given good service in bearings of internal combustion engines in spite of irregularities in lead content and distribution. No definite lead content would be established as optimum, but in general a low lead content favorably distributed was better than more lead in an unsuitable structure.

Aluminum alloys have been developed in which in a mildly hardened aluminum ground-mass low-melting, softer constituents are embedded—*e.g.* tin or lead. Such materials can be used with unhardened shafts because of their comparatively low hardness. When hardened steel shafts are used, such materials as "ALUGIR" (3% Cu, 0.8% Zn, 1-5% Ni, remainder aluminum) and "CHROMET" (10% Si, remainder aluminum) give good results.

Bonding of bushing and bearing, lining by casting-on and centrifugal casting, tables of wear data, shrinkage and tables giving suitable materials for various pressures and shaft speeds are reproduced from 41 references. Ha (3b)

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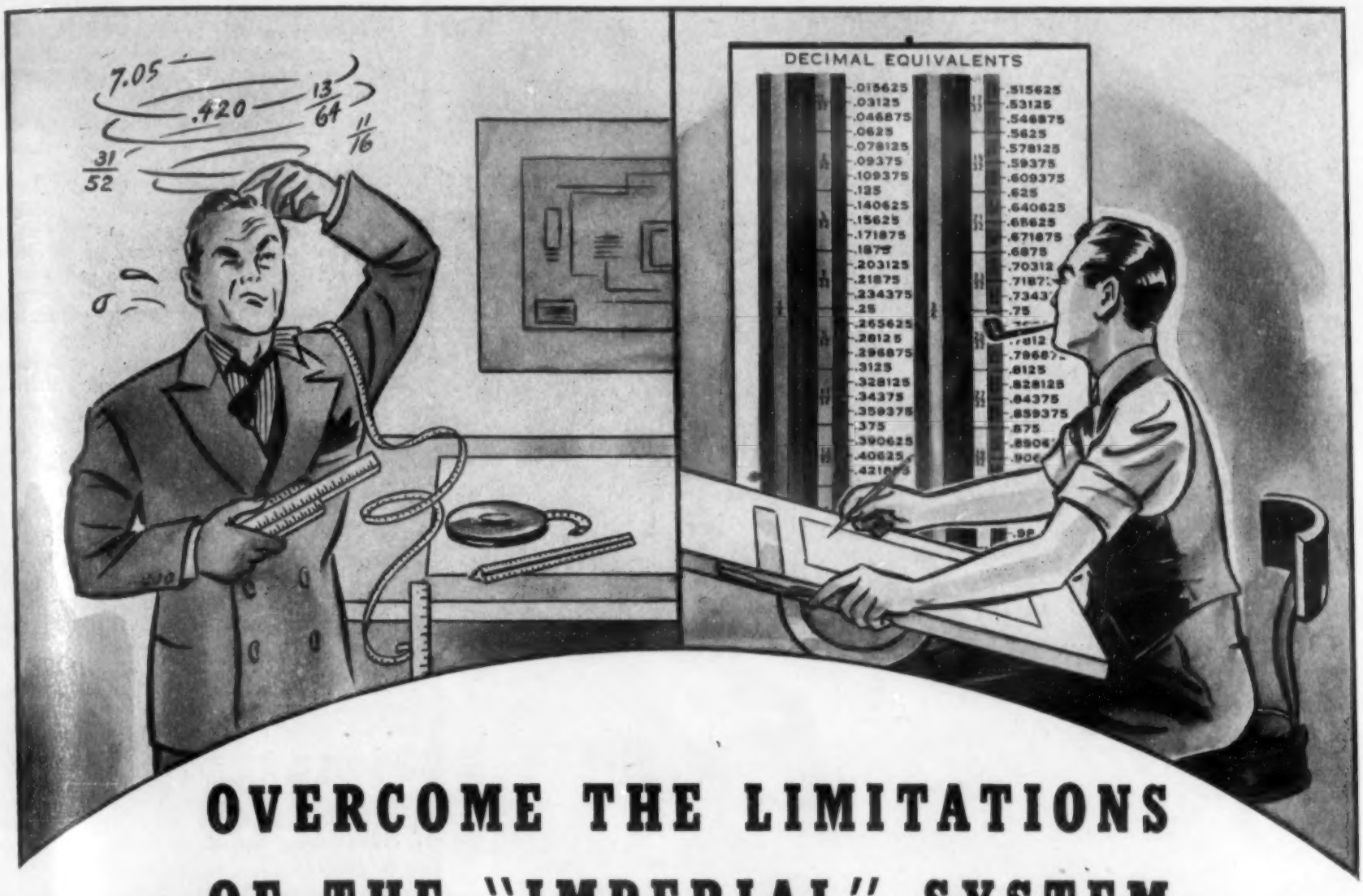

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The Tee Bend Test for Weldability

"The Tee Bend Test to Compare the Welding Quality of Steels." G. A. Ellinger, M. L. Williams & A. G. Bissell. *Paper, Am. Welding Soc.*, Oct. 1941 meeting.

The marked increase in the use of welded construction in place of riveted construction has involved more than a simple substitution of one method for the other. The design for riveted construction is not necessarily equally as suitable for welding; in fact, materially different designs are often necessary for identical structures fabricated by riveting and by welding.

Not all metals are equally satisfactory for welding and different welding techniques are necessarily employed for making the same types of joints in different metals. In selecting the metal best adapted for the strength requirements of the design and utility of a structure to be assembled by welding, the welding quality of the metal, within the limitations imposed by the practicability of the welding method, is of prime importance.

The welding of medium steel offers little difficulty provided proper attention is given to design and welding technique. However, the use of high tensile low alloy steels to reduce size and weight of members often create difficulties owing to differences in welding qualities of the steels.

In an investigation authorized by the Bur. of Ships and conducted at the National Bur. of Standards, the welding qualities of 18 commercial steels were studied by bending fillet welded tee specimens of the steels in special jigs. Six of these steels were also welded and tested at subnormal temperatures as low as — 20° F. The welds in the specimens were not machined.

The angle of bend at maximum load and the type of fracture in the bend test were the governing factors in comparing the welding qualities of the steels. The data were evaluated by means of a special method of statistical analysis which is described in detail.

Steels which contained large number of non-metallic inclusions generally had lower welding qualities than those which contained few inclusions. The high temperature grain size and grain coarsening temperatures apparently had little effect on the welding qualities of these steels. Steels normalized at 1650° F. before welding had higher welding qualities due probably to more homogeneous structures of the metals.

Hardness surveys indicated that none of the steels hardened appreciably upon welding and that there was no correlation between hardness properties and welding qualities as determined by this investigation. Likewise, no good correlation was found between the ordinary tensile properties (yield point, tensile strength and elongation) and welding qualities of these steels.

Steels welded at low temperatures usually had lower angles of bending and a higher percentage of failures in the parent metal than those welded at room temperature. However, the temperature at which the tests were made apparently had more effect on the results obtained than the temperature of the plates when welding was started.

Bend tests made on specimens of a steel with cast fillets and with welded fillets proved that the test was not a function of the geometrical shape of the specimen but was an indication of the welding quality of the steel. Likewise, the width of specimen is not critical and within certain limits does not appreciably affect the results of the bend tests. (4)

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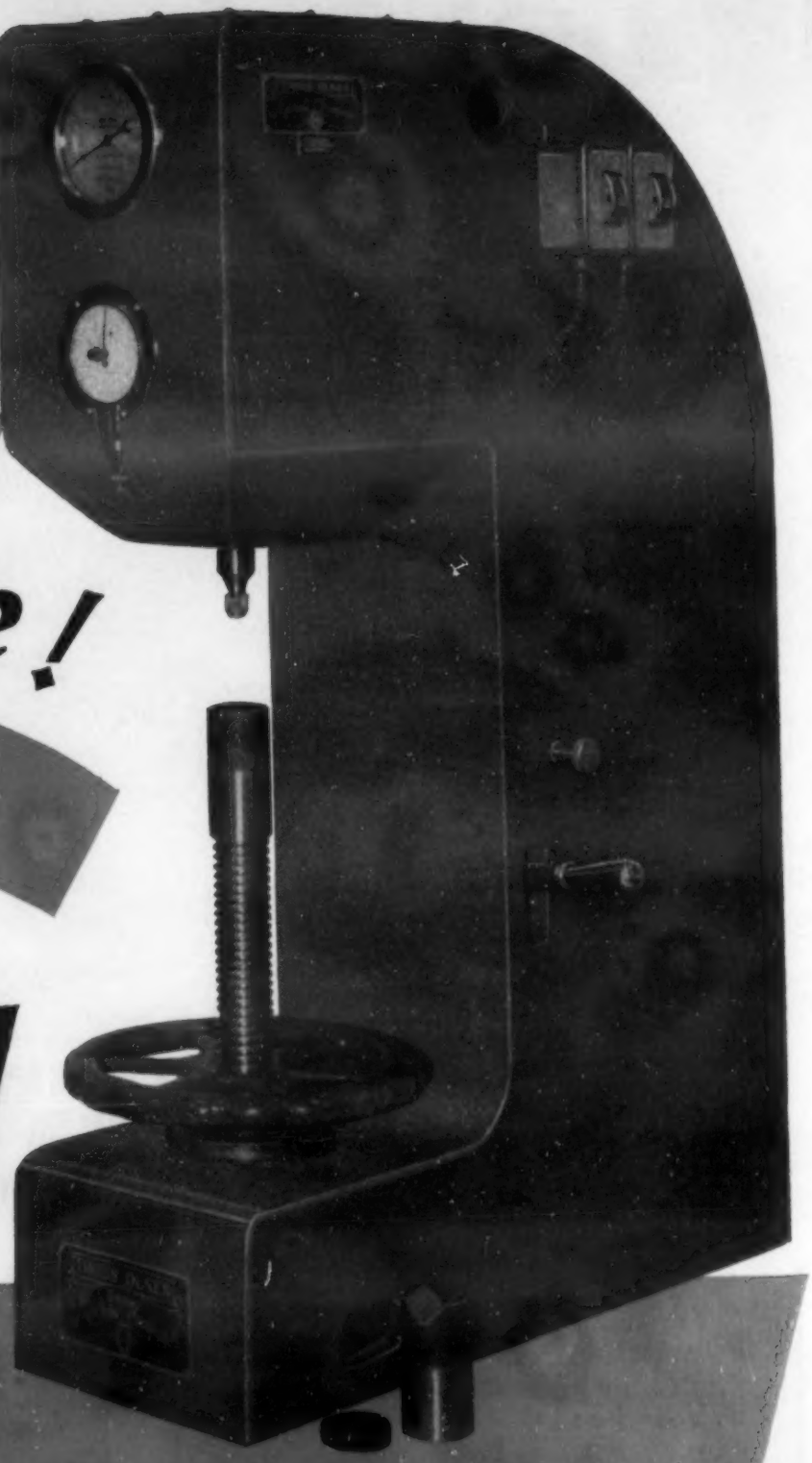

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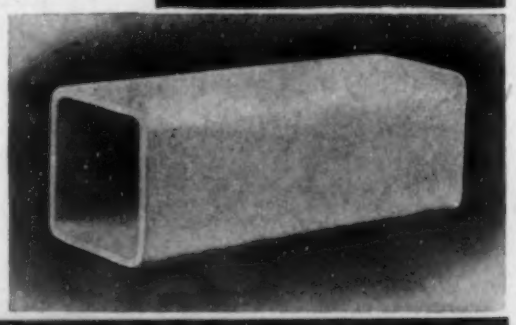

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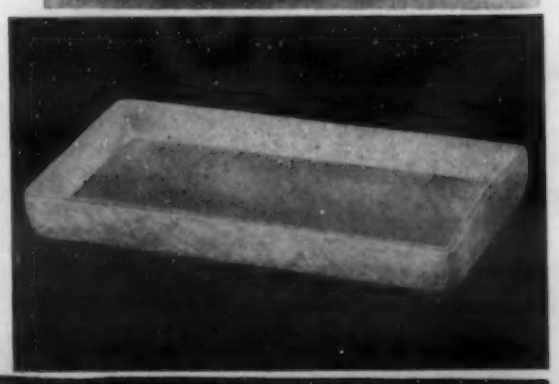

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Corrosion Test for Painted Iron

"Test for Corrosion of Painted Iron." R. B. Gibney (Bell. Tel. Labs.) *Bell Labs. Record*, Vol. 20, Oct. 1941, pp. 35-37. Research.

The described accelerated corrosion test to determine the corrosion of painted iron without destroying the paint film is based upon the fact that the potential of corroding metal becomes more electro-negative with time, while that of a metal which is not corroding becomes or remains electro-positive. The potential is measured by a calomel electrode which is connected with the paint film by a glass tube filled with water; an amplifier is necessary because of the very small currents involved.

Sets of panels prepared with various pigments were set up and conditioned at 68° F. and 50% relative humidity for a week. One set was subjected to outdoor exposure for a year, while time-potential curves were made on the other set. In the accelerated test, the significant factor was considered to be the time required for a curve to break and reach its lowest point.

Based on this factor, the paints were divided into four groups: (a) paints affording complete protection since no corrosion was indicated by the accelerated test after 100 hrs.; (b) paints showing corrosion in 20-100 hrs.; (c) paints failing in 5-20 hrs.; and (d) paints failing in less than 5 hrs.

Allowing a difference of one class for experimental error, the accelerated tests agreed with the outdoor tests in 18 out of 22 cases. In 3 of the other cases, the paint had broken in weathering, while in the fourth case the paint had improved on weathering so that a time-potential curve run on the exposed panel was better than the original one and agreed with the long time test.

Other tests confirmed this preliminary work and indicated that quick estimates obtained by electrochemical means agree with the results obtained on long time exposure tests except when there were changes in the paint film caused by the long exposure. JZB (4)

Spectrographic Study of Segregations in Large Forgings

"The Application of Spectrographic Methods to the Analyses of Segregates." F. G. Barker, J. Convey & J. H. Oldfield. *Iron & Steel Inst.*, Adv. Copy, July 1941, 11 pp. Investigation.

In developing a method for analyses of segregates in large forgings, pointed electrodes of either graphite or silver were used to form a spark between the segregate and the electrode of carbon or silver. A nipple-shaped silver electrode was found best for producing a small, well-defined crater in the segregate.

Relatively fast film was used and the gap reduced to 0.015 in. This permitted an exposure of only 15 sec. and the crater formed had a diameter of only 0.012 in. and a depth of 0.0007 in., which represents about 0.000,005 gram of steel.

Alloy steels, ground and etched to locate the segregates, were used, and definite increases in concentration of alloying elements were found in the segregates. A 15,000-volt spark without especially inserted inductance (capacity not stated) was used for the analyses.

Work is being continued to find whether or not there is a continuous variation of composition within each segregate. JLG (4)

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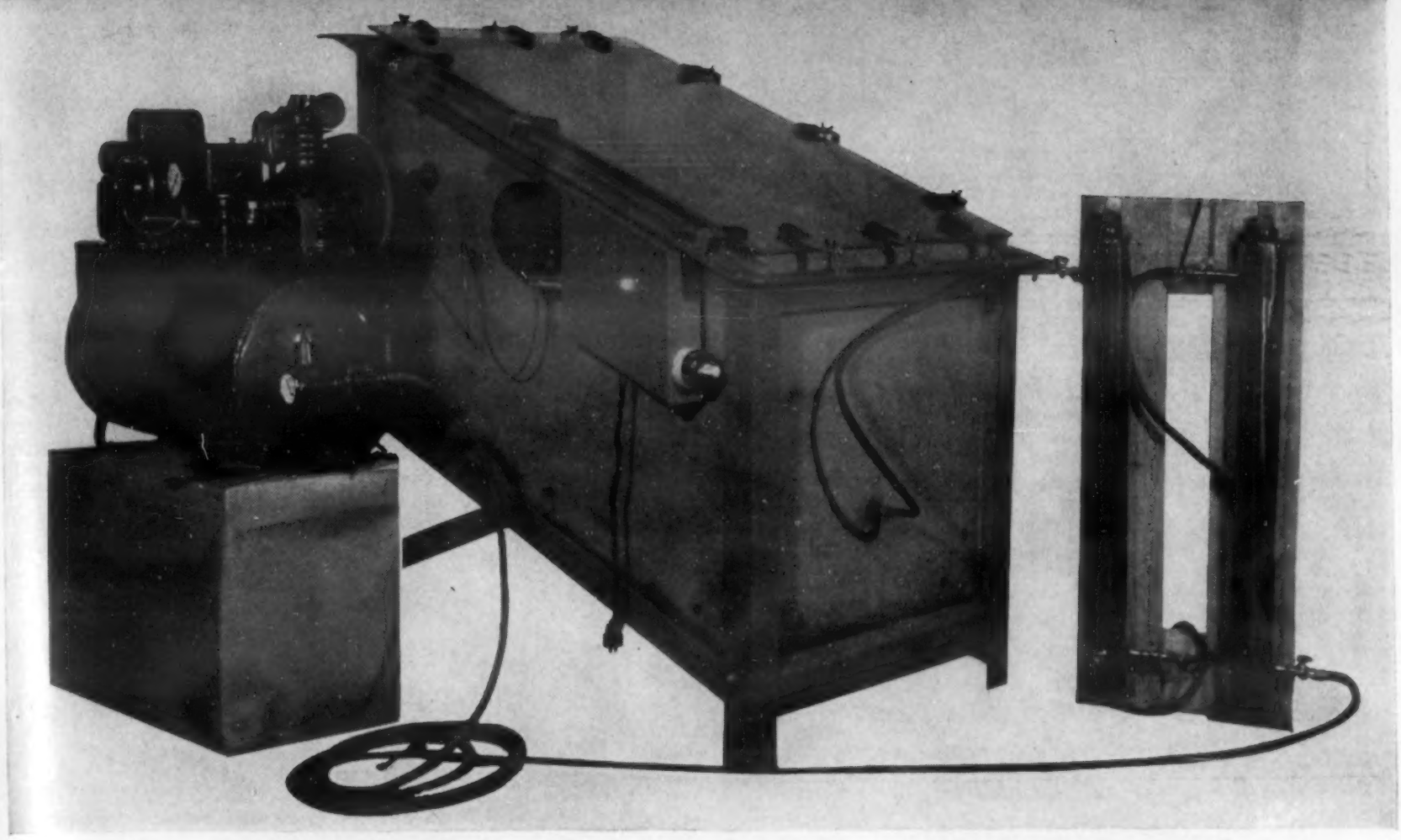

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Polishing Steel for Plating-Exposure Tests

"Polishing Steel Specimens Prior to Plating for Exposure Tests." Gerald A. Lux. *Proc. Am. Electroplaters' Soc.*, 1941, pp. 54-61. Research.

This is the first report of a joint research conducted by the American Electroplaters' Society and the National Bureau of Standards to determine the effect of variations in the procedure for polishing the base metal on the protective value of subsequently applied coatings.

Several methods are available for measuring the surface finish of polished specimens. The microscopic examination of a cross section is satisfactory, but the method is slow, and only a small cross-section can be examined. The brush surface analyzer is based on a piezoelectric crystal which converts the vertical movements of a stylus drawn across the specimen into a line tracing. The profilometer is based on the vertical movement of a coil, attached to a stylus, which produces a low voltage. Reflectivity measurements were not very satisfactory for evaluating surface finish.

The steel specimens were polished on a semi-automatic machine, using a glue wheel. All phases of the polishing operation, such as preparation of the abrasive wheels and the speeds and pressures used in polishing were carefully controlled.

The amount of steel removed in a single pass under the polishing wheel amounted to 0.0001-0.0005 in. of thickness. The amount of metal removed increased with the grain size and the wheel pressure used. For a given grain the wheel pressure used must represent a compromise, such as to give complete polishing of the surface without burning, yet yield a satisfactory life for the wheel.

During the life of a wheel, the depth of the scratches as measured with the profilometer, gradually becomes less, probably because the polishing grain breaks down. A given grain size produces the same depth of scratch regardless of the finish prior to polishing. The application of oil to polishing wheel heads reduces the amount of metal removed and the depth of scratch.

AB (4)

New Surface-Hardness Test

"Surface Hardness of Metals." Bruce Chalmers. *J. Inst. Metals*, Vol. 67, Oct. 1941, pp. 295-314. Descriptive.

A new method for determining surface hardness of metals is described. A known quantity of sand is dropped from a known height onto the surface whose hardness is to be measured, the surface being at an angle of 45° to the surface.

The specular reflection of the surface is determined before and after the sand is dropped. The amount of sand required to decrease the reflectivity by 50% is proportional to the hardness.

The relation between hardness values determined by the new method and Vicker hardness values is shown for materials whose hardness ranges from that for tin to that for speculum metal. JLG (4)

Testing Wall Thickness of Castings

"On Testing the Wall Thickness of Castings." B. M. Thornton & W. M. Thornton. *Foundry Trade J.*, Vol. 65, Oct. 16, 1941, pp. 253-254. Descriptive.

It is possible to determine the thickness of any casting, or whatever shape or material, within a few thousandths of an inch by the authors' method. The method is essentially that of comparing the resistance of a metal wall under test with that of a similar shaped wall of the same material of which the thickness is known. No knowledge of the specific resistance of the material is required.

Current, invariably under 10 amps. for castings, is supplied by a 6 or 12 volt battery to 2 current contacts held against the wall and spaced from 1 in. to 12 in. apart. In the majority of castings, the current contact spacing is 2 to 3 in.

The current in the circuit is adjusted by varying the rheostat until the potential drop indicated by the deflection of a galvanometer connected to 2 potential contacts spaced close to the current contacts reaches a predetermined fixed value. From a calibration curve the thickness of the wall corresponding to the current registered by the ammeter is determined.

The contacts are made on the wall of which thickness is to be measured by means of spring-controlled rotating points. The flexible leads connecting the contact heads with the instrument box are usually about 30 ft. long, although for special work they are sometimes 100 ft. long.

AIK (4)

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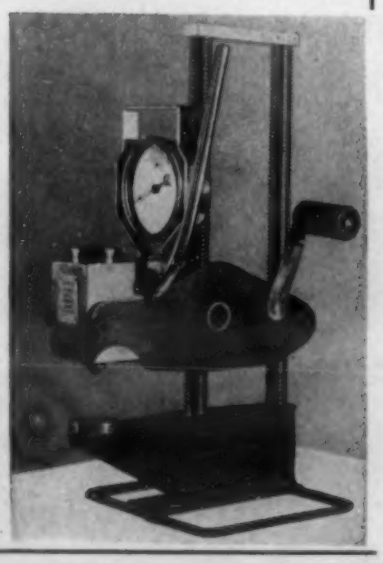

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